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The mission of **Sukkur IBA Journal of Computing and Mathematical Sciences (SJCMS)** is to provide a premier interdisciplinary platform to researchers, scientists and practitioners from the field of computing and mathematical sciences for dissemination of their finding and to contribute in the knowledge domain.

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3. To fill the gap between academician and industrial research community.

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- Robotics
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Prof. Nisar Ahmed Siddiqui
Sitara-e-Imtiaz
Director Sukkur IBA
Patron **SJCMS**

Editorial

Dear Readers,

I feel pleasure to present to you the first issue of Sukkur IBA Journal of Computing and Mathematical Sciences (SJCMS). As the mission statement of Sukkur IBA clearly demonstrates the importance of research, SJCMS is another remarkable effort of Sukkur IBA towards its commitment for creating a research-based community. The SJCMS provides an interdisciplinary platform to researchers, scientists, practitioners and academicians for publishing their contributions to the recent technological advances and innovations in the area of Computing and Mathematics for dissemination to the largest stakeholders.

The aim of this Journal is to publish original research findings in the field of Computing and Mathematics. Hence, it contains double-blind peer-reviewed articles which address key issues in the specified domains. The SJCMS adopts all standards that are a prerequisite for publishing high-quality research work. The Editorial Board of the Journal is comprised of academic and industrial researchers from technologically advanced countries. The Journal has adopted the Open access policy without charging any publication fees that will certainly increase the readership by providing free access to a wider audience.

On behalf of the SJCMS, I welcome the submissions for upcoming issue (Volume-1, Issue-2, July – December 2017) and looking forward to receiving your valuable feedback.

Sincerely,

Dr. Ahmad Waqas
Chief Editor
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WaterOnto: Ontology of Context-Aware Grid-Based Riverine Water Management System

Muhammad Hussain Mughal, Zubair Ahmed Shaikh
Centre for Research in Ubiquitous Computing, Mohammad Ali Jinnah University, Karachi, Pakistan
Muhammad.hussian@nu.edu.pk, Zubair.Shaikh@jinnah.edu

Abstract

The management of riverine water always remains a big challenge, because the volatility of water flow creates hurdles to determine the exact time and quantity of water flowing in rivers and available for daily use. The volatile water caused by various water sources and irregular flow pattern generates different kinds of challenges for management. Distribution of flow of water in irrigation network affects the relevant community in either way. In the monsoon seasons, river belt community high risk of flood, while far living community suffering drought. Contemplating this situation, we have developed an ontology for context-aware information representation of riverine water management system abetting the visualization and proactive planning for the complex real-time situation. The purpose of this WaterOnto is to improve river water management and enable for efficient use of this precious natural resource. This would also be helpful to save the extra water being discharged in sea & non-irrigational areas, and magnitude and location of water leakage. We conceptualized stakeholder and relevant entities. We developed a taxonomy of irrigation system concepts in machine process able structure. Being woven these hierarchies together we developed a detailed conceptualization of river flow that helps us to manage the flow of water and enable to extract danger situation.

Keywords: Irrigation water, Diversion, Reservoir, Web 3.0, Management, Ontology, Wireless Sensor Network, Semantic Modelling, software agents, Disaster

1. Introduction

In nature, water is the essential fluid from which all lives are created. All living things need water for survival. Water resources are sources of water that are useful or potentially useful to humans. Many uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. Only 2.5% of water on the Earth is fresh water, and over two-thirds of this are frozen in glaciers and polarize caps. Water demand already exceeds supply in many parts of the world, and many more areas are expected to experience this imbalance in the near future. Estimation theory claims that 70% of worldwide water use is for irrigation in agriculture. Climate change asserts significant impacts on water resources around the world owing to the close connections between the climate and hydrologic cycle. Due to the expanding human population competition for water is growing such that

many of the world's major aquifers are becoming depleted. Rivers are of immense importance geologically, biologically, historically and culturally. Although they contain only about 0.0001% of the total amount of water in the world at any given time. The rivers are vital carriers of water for irrigation and other nutrients provision source to the human body.

A grid-based wireless sensor assisted system was proposed in [1] and water monitoring Ontology [2] is the science of relationships how the things are related to each other. It seems as a complex stuff around but with the terms recognize globally and explicit implications streamline the contextual understanding standardization. We can achieve a well-established model of any phenomenon. Which helps us to relate objects and infer knowledge from given domain. Studer [3] Defines Ontology as an explicit representation of information that can be effected from temporal and spatial variations.

Rivers flow information changed spatially and temporally that need to be closely monitored pre-planning required for possible reactions to a disaster situation. Ontological represents semi-structured data in an efficient way along with contextual knowledge, particularly where stockholders having variation in major technical veracity and diversity. Sharing of information in a variety of formats is challenging task that is manageable by developing an ontology for information sharing. Ontology support interoperability and context information flow representation transitively assisting towards managing the provenance [4] of the system and decision can be retraced and evaluated for authenticity and efficacy of the information. The fundamental constructs of ontology include Classes, Relations, Axioms and Instances depict the domain knowledge in more comprehensive and natural semantic style with core concepts and their correlations. Semantic model [5] enables towards the design of automated system real-time monitoring. The classes represent concepts, which are taken in a broad sense [6] for all stakeholder in contextual computing environments. Collaborative interaction among concepts of similar and different domains are illustrated by to *Relations* [6]. Ontologies usually contain binary relations but increasing cardinality of association push towards course grain ontologies. Binary relation represents an association between the *domain* of the relation and *range*.

Axioms are used to associate class and property IDs with either partial or complete specification of their characteristics, and to give other logical information about classes and properties [7, 8]. A class axiom contains a collection of descriptions, which can be more general classes, restrictions, sets of individuals, and boolean combinations of descriptions. Ontology is exported in XMLs and regenerated in java like code. According to [9], *formal axioms* serve to model sentences that are always true. They are normally used to represent knowledge that cannot be formally defined by the other components. In addition, formal axioms are used to verify the consistency of the ontology itself or the consistency of the knowledge stored in a knowledge base. Formal axioms are very useful for inferring new knowledge. An axiom in the WaterGrid can infer list the causes of that variation flow using possibility theory [10].

Instances are used to represent elements or individuals in an ontology [6]. An example of an instance of the concept water low volume in Merab canal measured by Sensor WSN6321 on February 8, 2016, was 200 cubic meter per minute.

The effects of climate change are insidious and chronic that cannot be brought under control quickly, especially with the inadequate measures and unpredictable. Climate change and desertification should be considered globally as well as locally. Specific floods can also be caused by ice accumulation, a landslide in riverbeds and ice melting due to

high temperature, breach of embankments, drainage congestion etc. In this paper, we will discuss the ontology of Context-Aware Grid Based Riverine Water Management System through which we overcome following information issues:

- Time and quantity of water flowing in rivers and available for use of daily routine use in irrigation, household, industry, and sea to fulfill fresh water need for sea.
- Identification of major water level alteration trends, and sharing current situation information to relevant authorities for possible proactive measures through smart intelligent web 2.0 bases application [11].
- Reducing information format ambiguity and contextual statics for mitigation strategies through interoperable information sharing enables heterogeneous machine capable to process Ontology web language.

Developing domain knowledge for water management systems and interconnected disciplines for spatial- temporal situational variation.

2. Related Work

There is a few cite-worthy literature that reflects the sound knowledge of water management system and building a knowledge-base for river flow management and quality of water. They aim towards the management of water for irrigation purposes and disaster management responses. In general, all of them proposes the model-based management of water with geographical and climate concerns. In [12] authors discussed the methodology for the fusion of different geographic domain ontologies with top-level ontology, in order to provide a solid base for information exchange. Semantic factoring and concept lattices prove to be powerful tools in the formation and integration of geographic context. More specifically, the proposed methodology allows the detection of possible implicit relations between concepts what are not pre-defined, for example, the detection of hierarchical concept lattice includes new classes derived from the fusion or division of originally overlapping ones, which increase its semantic completeness. Thus, lattices [13], in contrast to trees and partially ordered sets, are richer structures, which conform the fundamentals characteristics of geographic categories, such as multidimensionality and the existence of overlapping relationships between them. Thus, it incorporates different, complementary conceptualizations of geographic space, each of which being suitable for some context and level of detail.

The architecture and implementation of a prototype ontology-based KM system [14] are developed for flow and water quality modeling. It adopts a three-stage life cycle for the ontology design and a Java/XML-based scheme for automatically generating knowledge search components. It is shown to be able to simulate human expertise during the problem solving by incorporating artificial intelligence and coupling various descriptive knowledge, procedural knowledge and reasoning knowledge involved in the coastal hydraulic and transport processes. Through the development of this prototype system, it has been demonstrated that the KM system can be integrated into the numerical flow and water quality modeling by incorporating AI technology to provide assistance on the selection of model and its pertinent parameters. The integration renders a more intelligent and user-friendly system in the problem domain, which can narrow significantly the gap between the numerical modelers and the application users. The prototype system demonstrates its capability in both the component reusability and the facilitation of knowledge acquisition and search.

The fundamental issue in the design of interoperable GIS for urban applications, the development and use of ontologies to support semantic interoperability [15]. The extensive ongoing research on interoperation of information has demonstrated the importance of allowing multiple information systems to share and exchange data across system boundaries [16]. Each layer constructs ontologies by first defining a generic functional model described by abstract data types, then domain ontologies are derived from the functional model by specializing its components and properties. We have presented several examples to illustrate how ontologies can be used in an application domain such as urban (traffic, electric, water, etc.) networks. The development of ontology is still hampered by the complexity. The isolating complex system by layers reduced a number of inherent properties from a large number of terms.

Ontologies based proposed solution are triggered by increasing complex natured numbers of natural and man-made disasters, such as earthquakes, tsunamis, floods, air crashes [7]. Post disasters recreation, rehabilitation, and restoration cost are ten times higher than pre-disaster mitigation strategies. This finding posed a challenge to the public and demonstrated the importance of disaster management authorities for proactive mitigation embedded solution of mechanically effort support by emerging technologically for context-awareness. The success of disaster management, amongst all, largely depends on finding and successfully integrating related information to make decisions during not only in response phase but equally in contingency planning. This information ranges from existing data to operational data. Most of this information is geographically related and therefore when discussing the integration of information for disaster management response, we often refer to the integration of geo-tempo information. Current efforts to integrate geo-temporal information have been restricted to keyword-based matching on Spatial Information Infrastructure (SII, may also know as Spatial Data Infrastructure). However, the semantic interoperability challenge is still underestimated. One possible way to deal with the problem is the use of ontology to reveal the implicit and hidden knowledge. This paper presents an approach for ontology development and ontology architecture, which can be used for emergency response and contingency planning.

3. Domain & Methodology

The domain of our project covers the management of water that is produced through melted glaciers and rainfall. Management contains the storage of water along with its distribution and overspill of water that causes damage to the irrigation land. The community affected by flood or drought disaster and irrigation fields productivity is another important stakeholder. We focused on main concepts includes:

1) Water diversion mechanism

2) Water reservation mechanism

3) Fusion of reservation and diversion mechanism for water flow control

4) Provision of the information into interoperable representation

5) Defining concepts for developing uniform domain understating

The layered architecture from data acquisition to decision level includes Data acquisition layer, Analysis layer, and Decision/Recommendation Layer [14]. In the Data Acquisition phase, the data generated from Wireless Water Sensor Network (WWSN) is aggregated local, sub-divisional, and divisional nodes then forwarded to the divisional server system for analysis. The analysis is performed based on a set of axioms defined over that subset of WWSN determines local contextual condition for current flow and identify the patterns. Then predefined policies and decision along with recommended mitigation strategies are adopted. In absence

of available mitigation strategy pattern, current information forwarded to responsible authorities. WaterOnto, an ontology-based knowledge management representation system enables the software agent [17-19] to react on the analysis information. The decision layer supports agents for decision connected for mitigation of flood disaster and efficient management of water-flow. The WaterOnto merges and enhances sub-ontologies of irrigation, water sources, consumption, and flow as shown in Fig.1. Processed and structured Statistical data assists the River flow management authorities for past pattern and current mitigation strategies. Interactive interface assists management authorities such as irrigation, disaster management and for sharing and using their relevant information WaterGrid would provide lives streams of river flow data that would be aggregated and validated at local and division levels before sharing to top management authorities.

3.1. Ontological conceptualization of River Management

The classes or terms we considered in our project are discussed gradually with descending order of contribution towards knowledge management. The two most

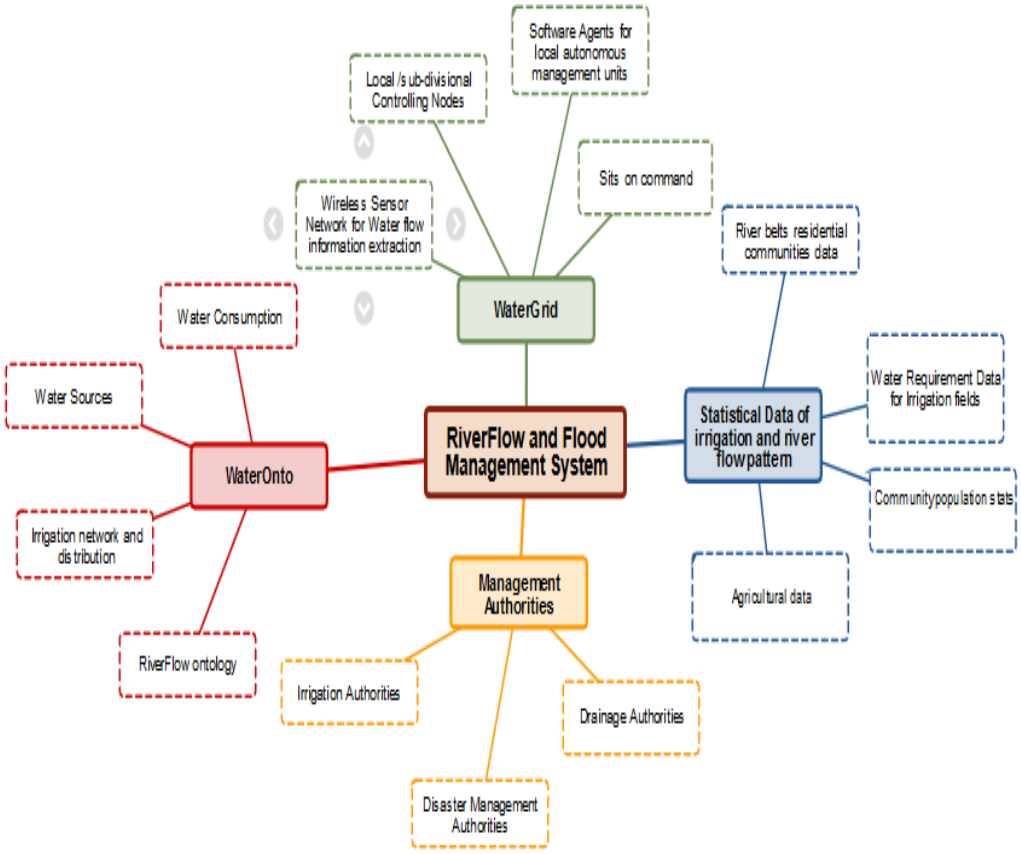

Figure. 1: Context diagram of Riverflow and Flood Management System

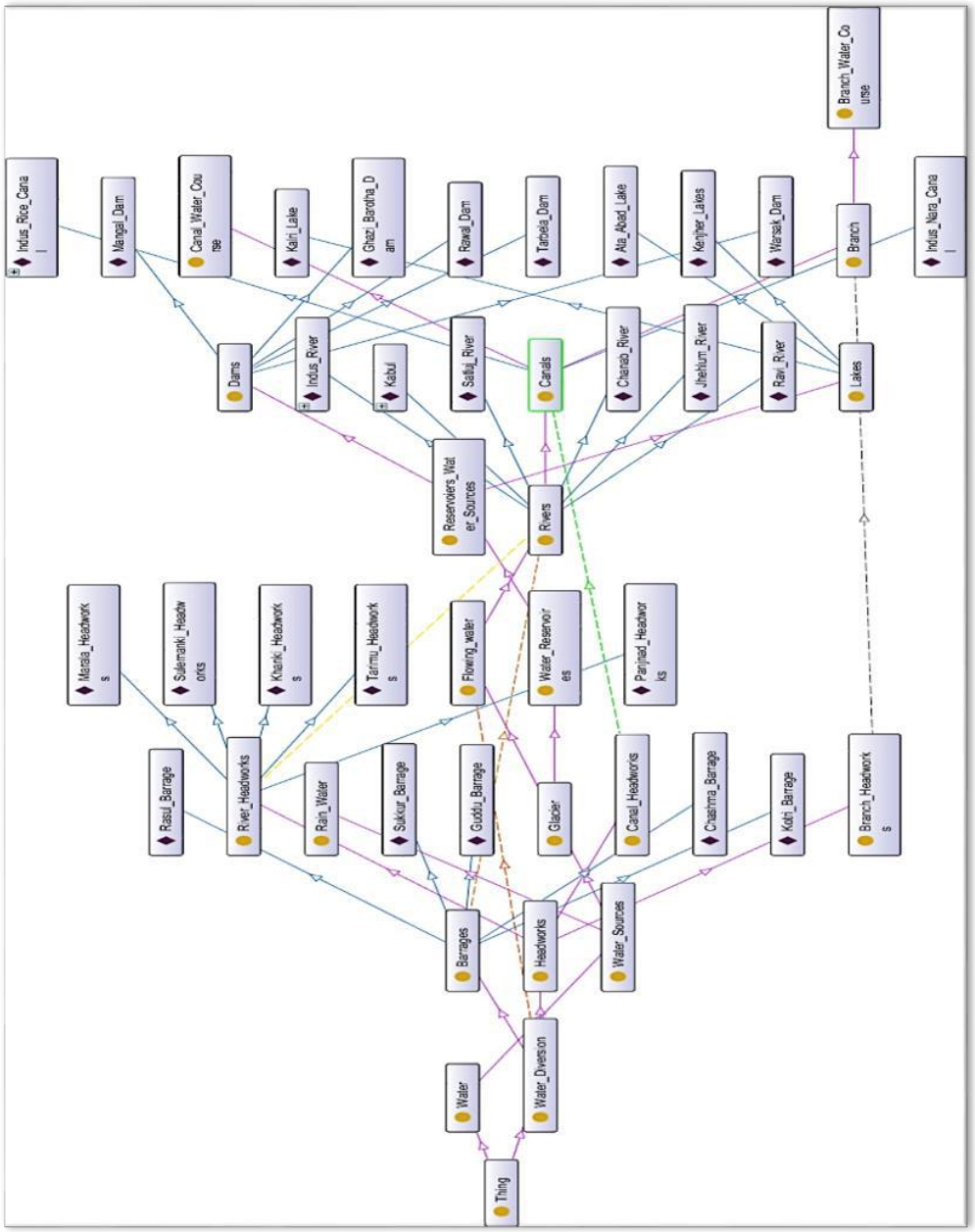

Figure. 2: A sub set of the ontology is show for representation

important concepts are water resource and management entities. The concept of river domain and their relation with other concepts is defined and represented in WaterOnto ontology. Water [20](a colorless, transparent, odorless liquid, which forms the seas, lakes,

rivers, rain and is the basis of the fluids of living organisms) is melted and flowed from Glaciers [20] (a slowly moving mass or river of ice formed by the accumulation and compaction of snow on mountains or near the poles). These solid glaciers are melted through warming factors such as sunlight and global warming elements and transformed into flowing water [20]. The Flow acceleration depends on the inclination angle of surface and viscosity of fluid. Due to the geographical oddness of planet this flowing water is then transformed into rivers [20] (A large natural stream of water flowing in a channel to the sea, a lake, or another river [20]) after merging through different spans of rocky area and mountain ranges. This geographical oddness also plays role in splitting rivers in short natural streams (a small, narrow river) and merging several streams together to form water reservoirs: Lake [20] (a large area of water surrounded by land). Lake is the natural means of storing water; in parallel, human-developed means to store water named Dams (a barrier constructed to hold back water and raise its level. Forming a reservoir used to generate electricity or as a water supply).

Moreover, we have many other water diversion mechanisms [20] which are applied on rivers such as Barrages (an artificial barrier across a river or estuary to prevent flooding, aid irrigation or navigation, or to generate electricity by tidal power). Barrages help us to divert and control the follow of the river of water. In most cases, barrages divert the flow of rivers towards dams and dams store the water and branch-outs different canals (an artificial waterway constructed to allow the passage of boats or ships inland or to convey water for irrigation). Further, we have diversion mechanism on canals called headwork [20] (apparatus for controlling the flow of water in a river or canal). These headworks manage the flow of water in different watercourses (a brook, stream, or artificially constructed water channel). These watercourses are used in irrigation lands and supplied to different tanks that supply water for the irrigation of fields, fish ponds, and domestic water supply purposes.

To conformance of the grid-based approach in our project, we have used object properties such as two different hierarchies i.e. flowing water and water diversions mechanisms, we have knit them, as they become grid in conceptual terms. Main object properties or relations in our project domain are merges_into_river, merges_into_dam, shoots canal, shoots watercourse, and diverts towards. The domains and ranges in ontology development are defined in WaterOnto. Thus, we define domain for merges_into_dam is flowing water (rivers and streams) and range is (dam), domain for merges_into_river is flowing water and range is rivers, domain for shoots canal is dam and range is canal, similarly domain for shoots watercourse is headwork's and range is watercourse and domain for diverts towards is barrage and range is dam. By using it we can weave the water flowing mechanism into water storage and water diversion mechanisms. A subset of the ontology is represented in Fig.2.

The data properties possess by the classes in our project are discussed in this section. Rivers hold information about WaterInFlow (measured in cusecs), WaterOutFlow (measured in cusecs), and Length (measured in feet). These properties manage and calculate the illegal usage of water like stealth and accidental breach of the river bank in between source and target of water flow mechanisms. Depth (measured in feet), Width (measured in feet) and name Canals and Watercourse holds same data properties as river provided. The other information includes location, which is measured by values of latitude and longitude and WaterInFlowTime and WaterOutFlowTime. Location helps us to determine the current outflow values which dam shoots out towards a particular canal along with diversion. Similarly headwork

shoots, which watercourse with its location and magnitudes. WaterInFlowTime and WaterOutFlowTime are captured to manage the flow of water (measured in cusec).This information is relatively important in order to calculate the deviation in flow with respect to normal flow and unpredictable situation calculation such as global warmings scale at glaciers. In the case of danger, prior information assists for mitigation strategies.

The proactive mitigation strategies include to alarm and prepare for a flood. The non-uniform melting problem results in variation of flow intensity. Concrete classes are rivers, dams, barrages, canals, headworks and watercourses. Individuals or objects are created from the hierarchy of the class and contextual semantic information will be based on the data generated from wireless sensor network proposed in WaterGird [1]. Low power WSN for calculating the flow of water discharge in canal and watercourse is developed [21]. A. Ontological conceptualization of Disaster Management, Rehabilitation, and other Supporting authorities.

The stakeholder authorities related to river management, Disaster Management, irrigation management, agricultural bodies, and communities. We encapsulated these authorities and defined their interaction relationship with each other in normal and danger situation. Irrigation authorities handle the flow of rivers, canals, and watercourse etc. Besides irrigation department, other departments also interested such as disaster management authorities, rehabilitation department, volunteers, NGO's.

The Indus basin the one major river covering 75% irrigation area [22] of Pakistan supported with others river joined into Indus after covering other upper regions commonly known as Indus River System. WWSN proposed WaterGrid would spread across the river belt and canals networks to provide real-time data to the aggregation sub-server nodes. The sparse matrix of sensor grid work in the normal situation and increase the on demand number WWSN and based on the criticality of danger situation. WaterGrid [1] is scalable and energy efficient computational model. To provide interoperability of the information and compatibility for Web 3.0, semantic representation of conceptualization of the domain knowledge facilitate the human and machine equally. The data extracted from WWSN the noise filtration applied to minimize the BER (Bit Rate Error). The filtered information further processed and transformed into ontology Web Language. WWSN IDs are coded with location and temporal context to increase the confidence level of decision support system. Functional and relational properties of corresponding authorities along their mandate of work are defined in WaterOnto. The decision support system extracts the data from contributing nodes and applies knowledge engine for decision support. A subset of classes, the individual provides data in waterOnto are shown in fig 3.

3.2. Location aware response strategies

To response real time situation, awareness about the location, current constraint imposed by local context, capacity of local authorities, accessibility routes to targeted location, capability of existing resources at particular location breach point of river, canals along with its effects on the community, irrigation fields can be determined by support of geographic information system [23]. We defined the GIS (Geographic Information System) concepts to supporting ontology of WaterOnto. The location is monitored from by GIS coordinates of the location and measure to respond the disaster situation, breach level, a nearby community, and attributes are calculated for effective response strategy. Depending on the magnitudes of danger the relevant authorities receives alerts, and early response can be provided with immediate availability of information. Semantic web and data with

RDF/XML, Ontology/XML enables the software agents to generate Early warning system from real contextual information. response strategy. A mobile application is designed extracts the information from volunteers, alter them on need by victim based

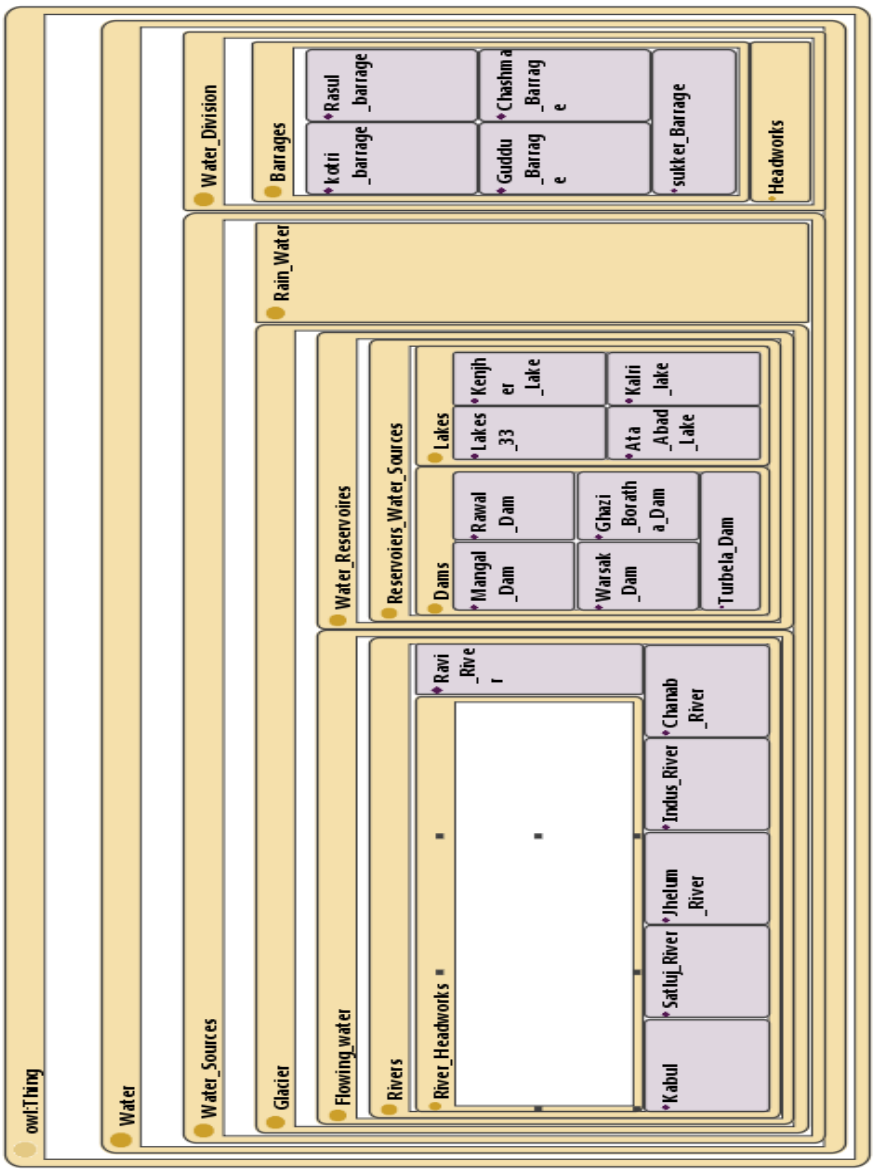

Figure. 3: A Subs Set of Classes and Individual in WaterOnto

Provide accurate and timely information for prompt and feasible response strategy. Complete coordination mechanism for on the services they can offer, their location, time to approach the victim. Further, application propagates the information about

NGOs and volunteer approached to victim community to other relevant NGOs and rehabilitation authorities registered through this app for efficient coordination [24]. This app used the structured processed data about flood and drought condition for broadcasting to volunteer and NGOs. This information will not only reduce the gap of missing affected community subset but also prove to strong real-time coordination tool to eliminate duplication of assistance. The systems updates database based on disaster information

4. Modularization Corresponding Ontologies

The modular approach resolves the complex domain problems to aspect-oriented [25] problem for simplicity and manageability. Development of a module for disaster management, rehabilitation department, volunteer organization, rural communities, irrigation, and agricultural, are defined in ontological conceptualization for representing interaction mechanism. For representing the relation we cite two relevant

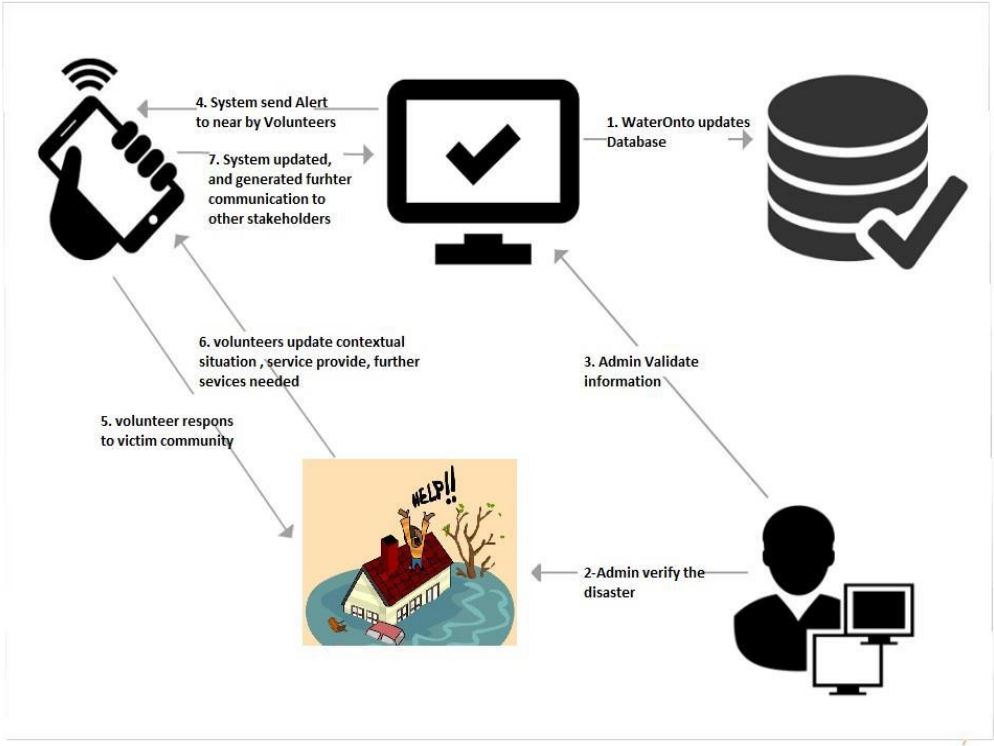

Figure. 4: Mobile Application for Response Strategies

provided by WaterOnto. Admin validates the disaster information, after confirmation by admin. The system will notify volunteers for their service to support victim community by guiding access path, community needs, and possible time to approach location. The software architecture for the app is shown in

domain with positive and negative consequence. Agricultural improvement portal was designed to improve the water utilization and improving the agricultural product. One of the main stakeholders of WaterOnto is a farmer that is interested in river water flow, dry season, availability of

water from river and rainforest casting for plan irrigation for cultivated their crops etc.
The concept of the representing a volunteer system is the modular approach towards the design of disaster management. The corresponding entities are conceptualized in the ontology for better understanding and contingency planning.

5. Conclusion

In this paper, we presented a simple approach for knitting the hierarchies of water producing sources and water distribution and diversion mechanisms such that it raise the phenomenon of context awareness in terms of water over flow form one node to another. Precisely it helps us in the optimal distribution of water to the irrigation land and will reduce the wastage of fresh water by sinking into the sea. We represented modular ontology development to simply the complexity of large scale system. We discussed the efficient water utilization and avoidance and response mechanism for the flood. The cross anthologies are developed for integrated system [5]. We proposed the integration of technology through semantic modeling. Machine process-able Data assist in improving the economy through better provision of irrigation to agricultural lands as well as household and industrial use. We also proposed integrated the disaster management authorities, response and rehabilitation authorities for automation on information processing and coordination.

6. Future Work

We would explore the details of the self-alarming system by utilizing machine learning approaches and climate and geographical factors that contribute to the damage and pollution of water supply. For example sedimentation and overflow that places a severe impact on water storage and wastage. The autonomous system needs to develop that recommend and automate based on information processed by WaterOnto after acquisition from WaterGird and then applying heuristic bases on combined human and machine intelligence for the optimal solution and proactive response strategies. Our future work will focus on: (1) a formal definition of the concepts used to create a multi- layered ontology, using different inter-related layers to reduce the number of terms that must be considered at each level; and (2) the design of tools to allow users to collaborate in the ontology generation process.

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Unsteady Incompressible Stokes Flow through Porous Pipe of Uniform Circular Cross Section with Periodic Suction and Injection

Kaleemullah Bhatti
Department of Mathematics and Social Science, Sukkur IBA Sukkur, Pakistan
kaleem.msmts@iba-suk.edu.pk
Abdul Majeed Siddiqui
Department of Mathematics, Pennsylvania State University, York Campus
York, PA 17403, U.S.A.
ams5@psu.edu
Zarqa Bano
Department of Mathematics and Social Science, Sukkur IBA Sukkur, Pakistan
zarqa.bano@iba-suk.edu.pk

Abstract

This work is concerned with the flow of a Newtonian fluid through a pipe of constant circular cross section which is uniformly porous. The governing unsteady equations are solved analytically after converting them to a third order ordinary differential equation using similarity transformation method. Expressions for axial and radial velocity components and pressure distribution are obtained. The characteristics of complex axial velocity and complex radial velocity for different values of parameters are analysed. The effects of small suction and small injection are delineated through graphs. Results reveal that suction or injection has significant influence on the flow.

Keywords: Unsteady Stokes Flow, Porous pipe, circular cross section, Periodic Suction and Injection, No Slip.

1. Introduction

Stokes flows or creeping flows are gaining importance because of their wide range of applications. Such type of flows occurs in lubrication process, in swimming of microorganism or sperm, in the flow of lava, in paints and viscous polymers etc. There are many real world flow situations that correspond to the laminar flow through a channel with porous walls. One of the applications is in the modeling of process such as transpiration cooling, in which walls of the channel are protected from the heat by injection of cooler fluids; another application is to model the fluid flow occurring during separation of isotopes of uranium-235 and uranium-238 by gaseous diffusion in order to produce fuel for nuclear reactors. Another situation in which flow through porous channels occur is in the model to control the boundary layer flow of air on the wings of aircrafts by injection or suction of fluids into or out of the wings. Some of such situations require one or both the walls of the channel to be porous.

Berman [1] (1953) was the first mathematician who encountered the problem of laminar flow through a porous channel of rectangular cross section. There was uniform injection through the lower plate and uniform suction through the upper plate. Narasimhan [6] (1961) extended the problem studied by Berman while considering flow of a non-Newtonian fluid through a uniform circular pipe. Khaled [5] (2004) studied the effect of slip conditions on Stokes and Couette flows due to oscillating wall. Ganesh [2] (2007) studied unsteady Stokes flow through a channel consisting of parallel porous plates when there is periodic suction through the lower plate and periodic injection through the upper plate. Zaman [4] (2013) considered the magneto-hydrodynamic fluid flow between parallel porous plates with uniform suction and injection. After that Kirubhashankar [3] (2014) studied the problem of unsteady magneto-hydrodynamic fluid flow through parallel porous plates when one plate was moving with constant velocity.

In this paper the flow of a Newtonian fluid through a uniformly porous pipe of constant circular cross is considered. The effects of small suction and small injection are delineated through graphs. Results reveal that suction or injection has significant influence on the flow.

2. Problem Formulation

We consider a circular pipe of uniform cross section and of infinite length and a Newtonian fluid passes through the pipe. The following flow assumptions are considered:

- Flow is axisymmetric with negligible body forces.
- Flow is unsteady.
- Stokes flow is presumed and therefore convective forces may be neglected in governing equations due to very small Reynolds Number.
- The walls of the cylindrical pipe are uniformly porous.
- The suction or injection occurs periodically through walls with velocity $v_0 e^{iwt}$.

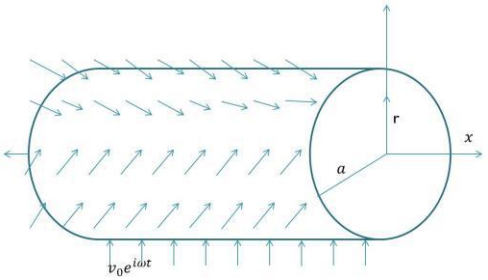

Fig. 1: Uniformly Porous Pipe with Circular Cross Section

We use cylindrical polar coordinates (r,θ,x) with x-axis as axial axis of pipe and r as radial distance from the axis. Due to axial symmetry θ coordinate disappears throughout. Defining a dimensionless parameter $= \frac{r}{a}, (0 \le \xi \le 1)$, where a is radius of the pipe and we are going to introduce this parameter in flow equations and boundary conditions as follows:

x-Component:

$$\frac{\partial u}{\partial t} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu\left(\frac{\partial^2 u}{\partial x^2} + \frac{1}{a^2}\frac{\partial^2 u}{\partial \xi^2} + \frac{1}{a^2 \xi}\frac{\partial u}{\partial \xi}\right), \quad (1)$$

r-Component:

$$\frac{\partial v}{\partial t} = -\frac{1}{a\rho}\frac{\partial p}{\partial \xi} + \nu\left(\frac{\partial^2 v}{\partial x^2} + \frac{1}{a^2}\frac{\partial}{\partial \xi}\left(\frac{1}{\xi}\frac{\partial}{\partial \xi}(\xi v)\right)\right), \quad (2)$$

Continuity Equation:

$$\frac{\partial}{\partial x}(\xi u) + \frac{1}{a}\frac{\partial}{\partial \xi}(\xi v) = 0, \quad (3)$$

where u and v are the velocity components in x and r direction in flow field at any

time t. The boundary conditions of the flow at any instant t are:

$$u(x,1)=0, \tag{4}$$

$$\left(\frac{\partial u}{\partial \xi}\right)_{\xi=0}=0, \tag{5}$$

$$v(x,0)=0, \tag{6}$$

$$v(x,1)=v_0 e^{iwt}. \tag{7}$$

We chose velocity vector $\mathbf{U}$ and pressure P in the form:

$$\vec{\mathbf{U}}=\left\{u(x,\xi)\hat{i}+v(x,\xi)\hat{j}\right\}e^{i\omega t}, \tag{8}$$

$$P=p(x,\xi)e^{i\omega t}. \tag{9}$$

Using equation (8) and equation (9) the governing equations (1) to (3) reduce to:

x -Component:

$$iwu=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\left(\frac{\partial^2 u}{\partial x^2}+\frac{1}{a^2}\frac{\partial^2 u}{\partial \xi^2}+\frac{1}{a^2\xi}\frac{\partial u}{\partial \xi}\right), \tag{10}$$

r -Component:

$$iwv=-\frac{1}{a\rho}\frac{\partial p}{\partial \xi}+\nu\left(\frac{\partial^2 v}{\partial x^2}+\frac{1}{a^2}\frac{\partial}{\partial \xi}\left(\frac{1}{\xi}\frac{\partial}{\partial \xi}(\xi v)\right)\right), \tag{11}$$

Continuity Equation:

$$\frac{\partial}{\partial x}(\xi u)+\frac{1}{a}\frac{\partial}{\partial \xi}(\xi v)=0, \tag{12}$$

The boundary conditions reduce to:

$$u(x,1)=0, \tag{13}$$

$$\left(\frac{\partial u}{\partial \xi}\right)_{\xi=0}=0, \tag{14}$$

$$v(x,0)=0, \tag{15}$$

$$v(x,1)=v_0. \tag{16}$$

3. Solution to the problem

Introducing the stream function ψ as follows, so that the continuity equation (12) is identically satisfied:

$$u(x,\xi)=\frac{1}{a^2\xi}\frac{\partial \psi}{\partial \xi}, \tag{17}$$

$$v(x,\xi)=-\frac{1}{a\xi}\frac{\partial \psi}{\partial x}. \tag{18}$$

Following the assumption of Berman [1] and Narasimhan [6], writing the stream function ψ as:

$$\psi(x,\xi)=g(x)h(\xi), \tag{19}$$

so that the velocities (17) and (18) are given as:

$$u(x,\xi)=\frac{1}{a^2\xi}g(x)h'(\xi), \tag{20}$$

$$v(x,\xi)=-\frac{1}{a\xi}g'(x)h(\xi). \tag{21}$$

The boundary conditions together with the knowledge of inlet conditions to the pipe give rise to an expression for $g(x)$.

$$g(x)=\frac{1}{h(1)}\left(\frac{a^2u_0}{2}-av_0x\right), \tag{22}$$

Where u_0 is the average axial velocity of fluid at the entrance of pipe and is given as follows:

$$u_0=2\int_0^1 \xi u(0,\xi)d\xi. \tag{23}$$

Assuming that:

$$\phi(\xi) = \frac{h'(\xi)}{\xi h(1)}, \tag{24}$$

$$\Phi(\xi) = \frac{h(\xi)}{\xi h(1)} = \frac{1}{\xi}\int_0^{\xi} t\phi(t)dt. \tag{25}$$

Using equations (24) and (25) we get the velocity components as follows:

$$u(x,\xi) = \left(\frac{u_0}{2} - \frac{xv_0}{a}\right)\phi(\xi), \tag{26}$$

and

$$v(x,\xi) = v_0\Phi(\xi), \tag{27}$$

and the stream function reduces to:

$$\psi(x,\xi) = \left(\frac{a^2u_0}{2} - av_0x\right)\xi\Phi(\xi). \tag{28}$$

In above equations the function $\phi(\xi)$ is still to be determined. It is also worth to mention that radial velocity becomes function of ξ only. Now using equations (26) and (27) in equations of motion (10) and (11) gives:

$$-\frac{1}{\rho}\frac{\partial p}{\partial x} = \left(\frac{u_0}{2} - \frac{xv_0}{a}\right)\left(iw\phi(\xi) - \frac{\nu}{a^2}\left(\phi''(\xi) + \frac{\phi'(\xi)}{\xi}\right)\right), \tag{29}$$

and

$$-\frac{1}{a\rho}\frac{\partial p}{\partial \xi} = iwv_0\Phi(\xi) - \frac{\nu v_0}{a^2}\left(\Phi''(\xi) + \frac{\Phi'(\xi)}{\xi} - \frac{\Phi(\xi)}{\xi^2}\right). \tag{30}$$

From onwards we would use the notations ϕ and Φ instead of $\phi(\xi)$ and $\Phi(\xi)$ in order to avoid repetition.

Differentiate equation (29) with respect to ξ to get:

$$-\frac{1}{\rho}\frac{\partial^2 p}{\partial\xi\partial x} = \left(\frac{u_0}{2} - \frac{x}{a}v_0\right)\left(iw\phi' - \frac{\nu}{a^2}\left(\phi''' + \frac{\phi''}{\xi} - \frac{\phi'}{\xi^2}\right)\right), \tag{31}$$

and differentiate equation (30) with respect to x to get:

$$-\frac{1}{\rho}\frac{\partial^2 \rho}{\partial x\partial\xi} = 0. \tag{32}$$

Equating the results of equation (31) equation (31) we get:

$$\left(\frac{u_0}{2} - \frac{x}{a}v_0\right)\left(iw\phi' - \frac{\nu}{a^2}\left(\phi''' + \frac{\phi''}{\xi} - \frac{\phi'}{\xi^2}\right)\right) = 0, \tag{33}$$

since this is to be satisfied for all x, therefore:

$$iw\phi' - \frac{\nu}{a^2}\left(\phi''' + \frac{\phi''}{\xi} - \frac{\phi'}{\xi^2}\right) = 0. \tag{34}$$

Assuming $\beta^2 = \frac{\rho iw}{\mu}$ equation (34) becomes:

$$\beta^2a^2\phi' - \left(\phi''' + \frac{\phi''}{\xi} - \frac{\phi'}{\xi^2}\right) = 0, \tag{35}$$

The boundary conditions on functions ϕ and Φ can be obtained using equations (26) and (27) and already prescribed boundary conditions (13) to (16) and are given below:

$$\phi(1) = 0, \phi'(0) = 0, \Phi(0) = 0, \Phi(1) = 1. \tag{36}$$

The third order linear ODE (35) together with the associated boundary (36) constitute an exact solution to equations of motion and continuity as formulated. Equation (35) is well known Modified Bessel's equation with order "$a\beta$". The general solution of equation (35) is easily obtained in terms of Modified Bessel functions as below:

$$\phi(\xi) = c_1 + c_2 I_0(a\beta\xi) + c_3 K_0(a\beta\xi), \quad (37)$$

where $I_\alpha(x)$ and $K_\alpha(x)$ are Modified Bessel functions of first and second kind respectively and are defined as follows:

$$I_\alpha(x) = \sum_{m=0}^{\infty} \frac{1}{m!\Gamma(m+\alpha+1)} \left(\frac{x}{2}\right)^{2m+\alpha}, \quad (38)$$

$$K_\alpha(x) = \frac{\pi}{2} \frac{I_{-\alpha}(x) - I_\alpha(x)}{\sin(\pi\alpha)}. \quad (39)$$

Since 1, $I_0(a\beta\xi)$ and $K_0(a\beta\xi)$ are three linearly independent solutions, therefore we can drop $K_0(a\beta\xi)$, having less contribution in solution. Also $K_0(a\beta\xi)$ diverges at $\xi = 0$ with singularity of logarithmic type. With this assumption equation (37) reduces to:

$$\phi(\xi) = c_1 + c_2 I_0(a\beta\xi). \quad (40)$$

Using substitution (25) and boundary conditions (36) we can easily find the values of arbitrary constants as given below:

$$c_1 = \frac{2a\beta I_0(a\beta)}{a\beta I_0(a\beta) - 2I_1(a\beta)}, \quad (41)$$

$$c_2 = \frac{-2a\beta}{a\beta I_0(a\beta) - 2I_1(a\beta)}. \quad (42)$$

Substituting these constants in general solution (40) we get:

$$\phi(\xi) = \frac{2a\beta(I_0(a\beta) - I_0(a\beta\xi))}{a\beta I_0(a\beta) - 2I_1(a\beta)}, \quad (43)$$

and using equation (25)

$$\Phi(\xi) = \frac{a\beta\xi I_0(a\beta) - 2I_1(a\beta\xi)}{a\beta I_0(a\beta) - 2I_1(a\beta)}. \quad (44)$$

Substitute $\phi(\xi)$ and $\Phi(\xi)$ in the components of velocity defined in equations (26) and (27) to get:

$$u(x,\xi) = \left(\frac{u_0}{2} - \frac{xv_0}{a}\right)\phi(\xi)$$

$$u(x,\xi) = \left(\frac{u_0}{2} - \frac{xv_0}{a}\right)\frac{2a\beta(I_0(a\beta) - I_0(a\beta\xi))}{a\beta I_0(a\beta) - 2I_1(a\beta)}, \quad (45)$$

and

$$v(x,\xi) = v_0\Phi(\xi)$$

$$v(x,\xi) = v_0 \frac{a\beta\xi I_0(a\beta) - 2I_1(a\beta\xi)}{a\beta I_0(a\beta) - 2I_1(a\beta)}. \quad (46)$$

Using equation (46) in equation (8), unsteady components of velocity are:

$$u(x,\xi,t) = \left(\frac{u_0}{2} - \frac{xv_0}{a}\right) \frac{2a\beta(I_0(a\beta) - I_0(a\beta\xi))}{a\beta I_0(a\beta) - 2I_1(a\beta)} e^{iwt}, \quad (47)$$

and

$$v(x,\xi,t) = v_0 \frac{a\beta\xi I_0(a\beta) - 2I_1(a\beta\xi)}{a\beta I_0(a\beta) - 2I_1(a\beta)} e^{iwt}. \quad (48)$$

Equations (47) and (48) now fully define the axial and radial velocity components respectively.Further introducing the following non-dimensional parameters:

$$N_{RE} = \frac{au_0}{\nu}, \quad (49)$$

$$R = \frac{av_0}{\nu}, \quad (50)$$

equations (47) and (48) can be written in non-dimensional form as follows:

$$\frac{u(x,\xi,t)}{u_0} = \left(\frac{1}{2} - \frac{x}{a}\frac{R}{N_{RE}}\right) \frac{2a\beta(I_0(a\beta) - I_0(a\beta\xi))}{a\beta I_0(a\beta) - 2I_1(a\beta)} e^{iwt}, \quad (51)$$

and

$$\frac{v(x,\xi,t)}{v_0} = \frac{a\beta\xi I_0(a\beta) - 2I_1(a\beta\xi)}{a\beta I_0(a\beta) - 2I_1(a\beta)} e^{iwt}. \quad (52)$$

The velocity field is now fully defined by equation (51) for axial component and by equation (52) for radial component.

4. Pressure Distribution

The pressure distribution can be obtained by extracting the pressure gradients from (29) and (30) and by integrating with respect to x and ξ respectively. Thus:

$$\int_0^x \frac{\partial p}{\partial x} dx = p(x,\xi) - p(0,\xi), \quad (53)$$

$$\int_0^\xi \frac{\partial p}{\partial \xi} d\xi = p(x,\xi) - p(x,0). \quad (54)$$

It follows from (53) and (54) that:

$$\int_0^x \frac{\partial p}{\partial x} dx + \left(\int_0^\xi \frac{\partial p}{\partial \xi} d\xi\right)_{x=0} = p(x,\xi) - p(0,0). \quad (55)$$

Using (29) and (30) we get:

$$p(x,\xi) = p(0,0) + \int_0^\xi \mu\left(-a\beta^2 v_0 \Phi(\xi) + \frac{v_0}{a}\left(\frac{d^2}{d\xi^2}\Phi(\xi) + \frac{\frac{d}{d\xi}\Phi(\xi)}{\xi} - \frac{\Phi(\xi)}{\xi^2}\right)\right) d\xi + \frac{1}{2}\frac{\mu v_0 x^2}{a}\left(\beta^2\phi(\xi) - \frac{1}{a^2}\left(\frac{d^2}{d\xi^2}\phi(\xi) + \frac{\frac{d}{d\xi}\phi(\xi)}{\xi}\right)\right) - \frac{1}{2}\mu u_0\left(\beta^2\phi(\xi) - \frac{1}{a^2}\left(\frac{d^2}{d\xi^2}\phi(\xi) + \frac{\frac{d}{d\xi}\phi(\xi)}{\xi}\right)\right)x, \quad (56)$$

(56)

and hence from equation (9)

$$P(x,\xi,t) = p(x,\xi)e^{i\omega t}, \quad (57)$$

where p(0,0) is pressure at the entrance of the channel. One can easily complete the calculations for pressure distribution by making the substitutions for $\phi(\xi)$ and

$\Phi(\xi)$ from equations (43) and (44) in the equation (56) and (57).

5. Results and Discussion

In this chapter the expressions for axial and radial velocity components for the two dimensional unsteady stokes flow through a pipe of uniform cross section and radius are obtained in equations (51) and (52). The case when 0<R≤1, where denotes wall Reynolds number, corresponds to small suction because wall velocity is taken positive in positive direction i.e., for suction. Hence if there is small suction through the porous pipe it can be clearly seen that the axial velocity decreases as fluid moves forward in the pipe in positive direction, see figures 2, 3, 4 and 8. The results may be justified with the argument that due to small suction internal pressure has been decreased.

The case when -1≤R<0 corresponds to small injection. and both are negative in the negative direction. Hence if the axial velocity increases as fluid moves forward in the pipe in positive direction, see figures 5, 6, 7 and 9. From figure 2 - 7 one can observe that the axial velocity completely vanishes when and behaves like a constant near the axis of the pipe i.e, from to and almost vanishes near the wall i.e, when $\xi = 1$.

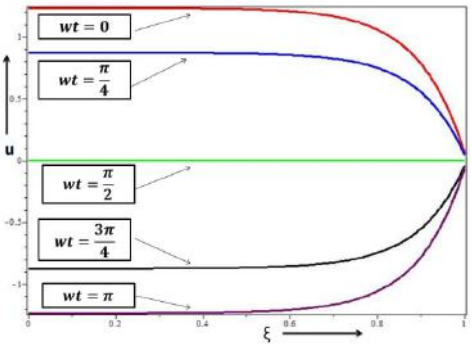

Figure 2: Axial velocity profile for small suction $R = 1 \;\; x = 0,\; a = 10,\; \beta = 1 \;\; N_{RE} = 10,$ *for few distinct values of wt*

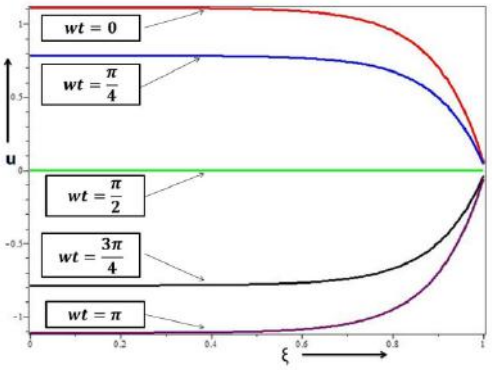

Figure 3: Axial velocity profile for small suction $R = 1 \;\; x = 5,\; a = 10,\; \beta = 1 \;\; N_{RE} = 10,$ *for few distinct values of wt*

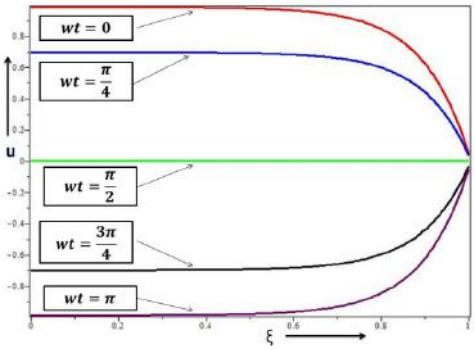

Figure 4: Axial velocity profile for small suction $R = 1 \;\; x = 10,\; a = 10,\; \beta = 1 \;\; N_{RE} = 10,$ *for few distinct values of wt*

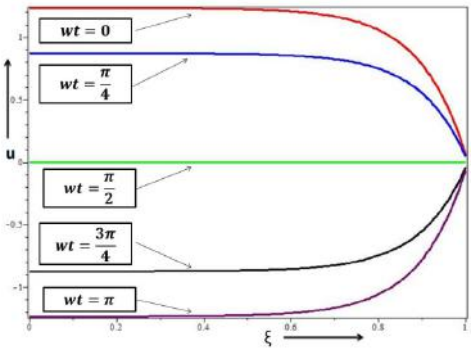

Figure 5: Axial velocity profile for small injection

$R=-1\ \ x=0,\ a=10,\ \beta=1\ \ N_{RE}=10$ *, for few distinct values of wt*

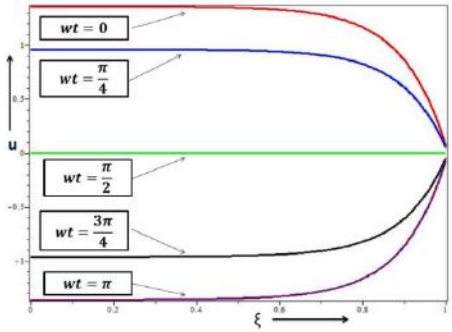

Figure 6: Axial velocity profile for small injection

$R=-1\ \ x=5,\ a=10,\ \beta=1\ \ N_{RE}=10$ *, for few distinct values of wt*

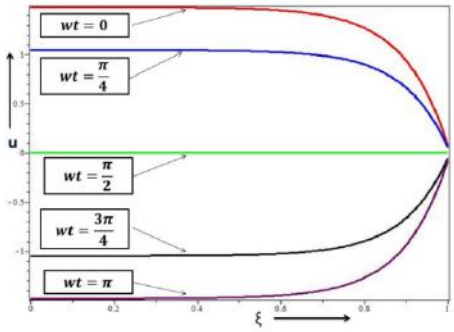

Figure 7: Axial velocity profile for small injection

$R=-1\qquad x=10,\qquad a=10,\qquad \beta=1$

$N_{RE}=10$ *, for few distinct values of wt*

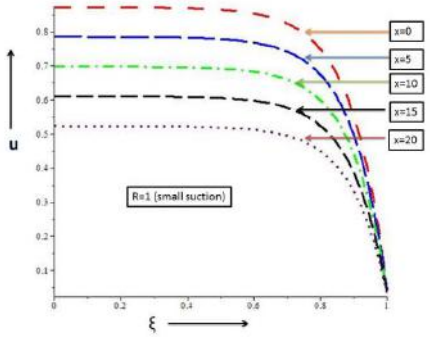

Figure 8: Axial velocity profile for small suction

$R=1,\qquad a=10,\qquad \beta=1\qquad N_{RE}=10,$

$wt=\dfrac{\pi}{4}$ *at few distinct cross sections of the pipe*

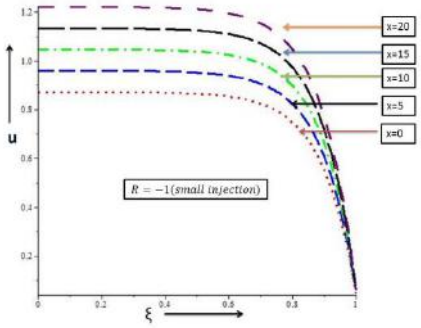

Figure 9: Axial velocity profile for small injection

$R=-1,\qquad a=10,\qquad \beta=1\qquad N_{RE}=10,$

$wt=\dfrac{\pi}{4}$ *at few distinct cross sections of the pipe*

6. Conclusion

Unsteady stokes flow of a Newtonian fluid past a pipe of uniform cross section have been discussed analytically, when there is periodic suction or periodic injection through its porous surface. The expressions for axial and radial velocity components and pressure distribution have been derived and analysed graphically for two cases i.e, for small suction and for small injection, depending on values of wall Reynolds number. It has been found that in case if there is small suction, the magnitude of axial velocity decreases and it increases if there is small injection.

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Necessary and Sufficient Conditions for Complementary Stochastic Quadratic Operators of Finite-Dimensional Simplex

Rawad Abdulghafor, Sherzod Turaev, Akram Zeki,
Collage of Information and Communication Technology, International Islamic University Malaysia, 53100,Kuala Lumpur, Malaysia
raaac2004@yahoo.com
sherzod@iium.edu.my, akramzeki@iium.edu.my

Abstract

We define a complementary stochastic quadratic operator on finite-dimensional space as a new sub-class of quadratic stochastic operator. We give necessary and sufficient conditions for complementary stochastic quadratic operator.

Keywords: Quadratic stochastic operators, complementary stochastic quadratic operator, finite-dimensional space, Sub-stochastic matrix

1. Introduction

A quadratic stochastic operator is a general nonlinear model traced back to [1]. A lot of research have been devoted to investigations of various sub-classes of quadratic stochastic operator such as doubly stochastic quadratic operators, dissipative of quadratic stochastic operators, volterra quadratic stochastic operators and extreme doubly stochastic quadratic operators [2]–[7]. In recent years, this theory has become of a great interest in its multiple applications to the problems of population genetics [8]–[10] and control systems [11], [12]. During the past 80 years, nonlinear models have been focused in many researches due to their efficiency as well as their advantages over linear models [13], [14].

In effect, this motivates the study of a new nonlinear model in this paper. The central and main problem in nonlinear models of the family classes of quadratic stochastic operator is to study the limit behaviour their related trajectories. This is true as such nonlinear have complicated structure. This paper focuses on defining a nonlinear model with less complex structure.

2. Preliminaries

A quadratic stochastic operator is formed as follows:

$$(\mathrm{Vx})_{\mathrm{k}} = \sum_{\mathrm{i,j=1}}^{\mathrm{m}} \mathrm{p_{ij,k}}\ \mathrm{x_i} x_j, \qquad (1)$$

where

$$x \in S^{m-1} = \{x = (x_1, x_2, \dots, x_m) \in R^m : x_i \geq 0, \forall_i = \overline{1,m}, \sum_{i=1}^{m} x_i = 1\} \qquad (2)$$

and the coefficients $p_{ij,k}$ satisfy the conditions

$$p_{ij,k} = p_{ji,k} \geq 0, \sum_{k=1}^{m} p_{ij,k} = 1. \quad (3)$$

A quadratic stochastic operator is defined on a free population space. In meaning, suppose that the free space of population involves a set of m elements. This set is defined on a simplex as in Equation 2, and it is termed as an $(m-1)$-dimensional simplex.

A quadratic stochastic operator assigned the same simplex, $V: S^{m-1} \rightarrow S^{m-1}$, is formed as in Equation 1.

The maps among the elements x_i are considered as a distributed stochastic matrix given by

$$p_{ij,k} = (p_{ij,1}, p_{ij,2}, \dots, p_{ij,k}) \quad (4)$$

where $p_{ij,k}$ is considered under the conditions of Equation 3.

In this paper, we define a new model of complementary stochasticity quadratic operators from the general model of quadratic stochastic operator under some derived some conditions included in $p_{ij,k}$. The concept of the complementary stochasticity quadratic operators is explored in the next section.

3. Complementary Stochasticity Quadratic Operators

As known that $p_{ij,k}$ is a stochastic matrix of the distribution matrices $(p_{ij,1}, p_{ij,2}, \dots, p_{ij,k})$ in the operator $V(x): S^{m-1} \rightarrow S^{m-1}$ as given in Equation 1.

Definition: An operator $V(x)$ is called complementary stochasticity quadratic if has a complementary stochastic matrix P, then $V(x) = Px$, where P is a matrix (m $\times$ m). $P = [p_{ij,k}]$ is said to be a complementary stochastic matrix if

i) for all $1 \leq i \neq \leq m, p_{ij,k} = p_{ji,k} = 0$ or $p_{ji,k} \neq 0$ and $p_{ji,k} = 1 - p_{ij,k}$.
ii) For all $1 \leq i \leq m, p_{ii,k} = 0$ or $p_{ii,k} = \frac{1}{2}$.
iii) For all distributed matrices $P_{ij,k} = (p_{ij,1}, p_{ij,2}, \dots, p_{ij,k}), \sum_{ij=1}^{m} p_{ij,k} = m, \sum_{k=1}^{m} p_{ij,k} = 1$.

Therefore, the new notations for complementary stochasticity quadratic operators for matrices $(p_{ij,1}, p_{ij,2}, \dots, p_{ij,k})$ are

$$U_{low} = \left\{ \begin{matrix} p_{ii,k} = \frac{1}{2} \vee 0, p_{ji,k} = 1 - p_{ij,k} \; or \; 0, \\ \sum_{ij=1}^{m} p_{ij,k} = m, \sum_{k=1}^{m} p_{ij,k} = 1 \end{matrix} \right\} \quad (5)$$

where $p_{ii,k}$ are the diagonal elements limited to either 0 or $\frac{1}{2}$, each symmetric element is stochastic $p_{ij,k} + p_{ji,k} = 1$ with respect that the elements' sum of each distributed matrix $p_{ij,k}$ begin equal to m and the summation of all distributed matrices $\left(p_{ij,1}, p_{ij,2}, \dots, p_{ij,k}\right)$ is a matrix that has all of its elements equal to 1.

The key idea in complementary stochasticity quadratic operators is to make the coefficient of the elements equal to 1 or0. The distributed matrices $p_{ij,k} = (p_{ij,1}, p_{ij,2}, \dots, p_{ij,k})$ are structured as

$$\begin{pmatrix} a_{11,1} & a_{12,1} & \dots & a_{1m,1} \\ 1 - a_{12,1} & a_{22,1} & \dots & a_{2m,1} \\ \vdots & \vdots & \ddots & \vdots \\ 1 - a_{1m,1} & 1 - a_{2m,1} & \dots & a_{mm,1} \end{pmatrix} +$$

$$\begin{pmatrix} a_{11,2} & a_{12,2} & \dots & a_{1m,2} \\ 1-a_{12,2} & a_{22,2} & \dots & a_{2m,2} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,2} & 1-a_{2m,2} & \dots & a_{mm,2} \end{pmatrix} + \begin{pmatrix} \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \vdots & \vdots & \ddots & \vdots \\ \dots & \dots & \dots & \dots \end{pmatrix} + \begin{pmatrix} a_{11,m} & a_{12,m} & \dots & a_{1m,m} \\ 1-a_{12,m} & a_{22,m} & \dots & a_{2m,m} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,m} & 1-a_{2m,m} & \dots & a_{mm,m} \end{pmatrix} = \begin{pmatrix} 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \ddots & \vdots \\ 1 & 1 & \cdots & 1 \end{pmatrix} \quad (6)$$

referring to the evaluation operator in Equation 1, the analytical procedure of this method is as follows:

$$\sum_{i,j=1}^{m} x_i\, p_{ij,k}\, x_j = \begin{pmatrix} (x_1 \;\; x_2 \;\; \dots \;\; x_m) \begin{pmatrix} a_{11,1} & a_{12,1} & \dots & a_{1m,1} \\ 1-a_{12,1} & a_{22,1} & \dots & a_{2m,1} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,1} & 1-a_{2m,1} & \dots & a_{mm,1} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix} \\ (x_1 \;\; x_2 \;\; \dots \;\; x_m) \begin{pmatrix} a_{11,2} & a_{12,2} & \dots & a_{1m,2} \\ 1-a_{12,2} & a_{22,2} & \dots & a_{2m,2} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,2} & 1-a_{2m,2} & \dots & a_{mm,2} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix} \\ \vdots \\ (x_1 \;\; x_2 \;\; \dots \;\; x_m) \begin{pmatrix} a_{11,m} & a_{12,m} & \dots & a_{1m,m} \\ 1-a_{12,m} & a_{22,m} & \dots & a_{2m,m} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,m} & 1-a_{2m,m} & \dots & a_{mm,m} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix} \end{pmatrix}$$

where a_{ij} is the coefficient among the two points x_i and x_j and $(x_1, x_2, \dots, x_m)$ are vector of points.

Then, the evaluation of the nonlinear operator $V(x)$ is calculated as follows:

$$\sum_{i,j=1}^{m} x_i\, p_{ij,k}\, x_j = \begin{pmatrix} (x_1 \;\; x_2 \;\; \dots \;\; x_m) \begin{pmatrix} a_{11,1} & a_{12,1} & \dots & a_{1m,1} \\ 1-a_{12,1} & a_{22,1} & \dots & a_{2m,1} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,1} & 1-a_{2m,1} & \dots & a_{mm,1} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix} \\ (x_1 \;\; x_2 \;\; \dots \;\; x_m) \begin{pmatrix} a_{11,2} & a_{12,2} & \dots & a_{1m,2} \\ 1-a_{12,2} & a_{22,2} & \dots & a_{2m,2} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,2} & 1-a_{2m,2} & \dots & a_{mm,2} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix} \\ \vdots \\ (x_1 \;\; x_2 \;\; \dots \;\; x_m) \begin{pmatrix} a_{11,m} & a_{12,m} & \dots & a_{1m,m} \\ 1-a_{12,m} & a_{22,m} & \dots & a_{2m,m} \\ \vdots & \vdots & \ddots & \vdots \\ 1-a_{1m,m} & 1-a_{2m,m} & \dots & a_{mm,m} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix} \end{pmatrix}$$

$$(x_i) \begin{cases} V(x_1) = a_{11,1}x_1x_1 + a_{12,1}x_1x_2 + \cdots + a_{1m,1}x_1x_m + a_{21,1}x_2x_1 + a_{22,1}x_2x_2 + \\ \quad \dots + a_{2m,1}x_2x_m + \cdots \dots + a_{m1,1}x_mx_1 + a_{m2,1}x_mx_2 + \cdots + a_{mm,1}x_mx_m, \\ V(x_2) = a_{11,2}x_1x_1 + a_{12,2}x_1x_2 + \cdots + a_{1m,2}x_1x_m + a_{21,2}x_2x_1 + a_{22,2}x_2x_2 + \\ \quad \dots + a_{2m,2}x_2x_m + \cdots \dots + a_{m1,2}x_mx_1 + a_{m2,2}x_mx_2 + \cdots + a_{mm,2}x_mx_m, \\ \quad \vdots \quad = \quad \vdots \quad + \quad \vdots \quad + \quad \vdots \quad + \quad \vdots \quad + \quad \vdots \quad + \quad \vdots \quad + \quad \vdots \quad + \quad \vdots \\ V(x_m) = a_{11,m}x_1x_1 + a_{12,m}x_1x_2 + \cdots + a_{1m,m}x_1x_m + a_{21,m}x_2x_1 + a_{22,m}x_2x_2 + \\ \quad \dots + a_{2m,m}x_2x_m + \cdots \dots + a_{m1,m}x_mx_1 + a_{m2,m}x_mx_2 + \cdots + a_{mm,m}x_mx_m, \end{cases} \quad (8)$$

4. Some Examples Of Complementary Stochasticity Quadratic Operators

1. Example 1, operator $V_1(x)$ with $m = 3$: In the case of distributed matrices $p_{ij,k}$, there are three as follows

$$p_{ij,k} = \begin{cases} p_{ij,1} = \begin{pmatrix} 0 & 0 & 0.9 \\ 0 & 0.5 & 0.4 \\ 0.1 & 0.6 & 0.5 \end{pmatrix}, p_{ij,2} = \begin{pmatrix} 0.5 & 0 & 0.1 \\ 1 & 0.5 & 0 \\ 0.9 & 0 & 0 \end{pmatrix}, p_{ij,3} \\ = \begin{pmatrix} 0.5 & 1 & 0 \\ 0 & 0 & 0.6 \\ 0 & 0.4 & 0.5 \end{pmatrix}. \end{cases}$$

Using Equation (7) then we get

$$V_1(x) \begin{cases} X_1 = x_1x_3 + x_2x_3 + \dfrac{{x_2}^2}{2} + \dfrac{{x_3}^2}{2} \\ X_2 = x_1x_2 + x_1x_3 + \dfrac{{x_1}^2}{2} + \dfrac{{x_2}^2}{2} \\ X_3 = x_1x_2 + x_2x_3 + \dfrac{{x_1}^2}{2} + \dfrac{{x_3}^2}{2} \end{cases}$$

2. Example 2, operator $V_2(x)$ with $m = 3$: In the case of distributed matrices $p_{ij,k}$, then there are three and given by

$$p_{ij,k} = \begin{cases} p_{ij,1} = \begin{pmatrix} 0 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0 \\ 0.5 & 0 & 0.5 \end{pmatrix}, p_{ij,2} = \begin{pmatrix} 0.5 & 0.5 & 0 \\ 0.5 & 0 & 0.5 \\ 0 & 0.5 & 0.5 \end{pmatrix}, \\ p_{ij,3} = \begin{pmatrix} 0.5 & 0 & 0.5 \\ 0 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0 \end{pmatrix}. \end{cases}$$

Similarly, sing Equation (7) then we get

$$V_2(x)\begin{cases} X_1 = x_1x_2 + x_1x_3 + \frac{{x_2}^2}{2} + \frac{{x_3}^2}{2} \\ X_2 = x_1x_2 + x_2x_3 + \frac{{x_1}^2}{2} + \frac{{x_3}^2}{2} \\ X_3 = x_1x_3 + x_2x_3 + \frac{{x_1}^2}{2} + \frac{{x_2}^2}{2} \end{cases}$$

3. Example 3, operator $V_3(x)$ with $m = 4$: In the case of distributed matrices $p_{ij,k}$, there are four

$$= \begin{cases} p_{ij,1} = \begin{pmatrix} 0.5 & 0 & 0 & 0.2 \\ 0 & 0.5 & 0 & 0 \\ 0 & 0 & 0.5 & 0.6 \\ 0.8 & 0 & 0.4 & 0.5 \end{pmatrix}, p_{ij,2} = \begin{pmatrix} 0.5 & 1 & 0.7 & 0 \\ 0 & 0 & 0 & 0.6 \\ 0.3 & 0 & 0.5 & 0 \\ 0 & 0.4 & 0 & 0 \end{pmatrix}, \\ p_{ij,3} = \begin{pmatrix} 0. & 0 & 0.3 & 0 \\ 0 & 0 & 0 & 0.4 \\ 0.7 & 1 & 0 & 0.4 \\ 0 & 0.6 & 0.6 & 0 \end{pmatrix}, p_{ij,4} = \begin{pmatrix} 0 & 0 & 0 & 0.8 \\ 1 & 0.5 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0.2 & 0 & 0 & 0.5 \end{pmatrix}. \end{cases}$$

Using Equation (7) again, we get

$$V_3(x)\begin{cases} X_1 = x_1x_4 + x_3x_4 + \frac{{x_1}^2}{2} + \frac{{x_2}^2}{2} + \frac{{x_3}^2}{2} + \frac{{x_4}^2}{2} \\ X_2 = x_1x_2 + x_1x_3 + x_2x_4 + \frac{{x_1}^2}{2} + \frac{{x_3}^2}{2} \\ X_3 = x_1x_3 + x_2x_3 + x_2x_4 + x_3x_4 \\ X_4 = x_1x_2 + x_1x_4 + x_2x_3 + \frac{{x_2}^2}{2} + \frac{{x_4}^2}{2} \end{cases}$$

4. Example 4, operator $V_4(x)$ with $m = 4$: In the case of distributed matrices $p_{ij,k}$, there are four

$$p_{ij,k} = \begin{cases} p_{ij,1} = \begin{pmatrix} 0 & 0.6 & 0.4 & 0 \\ 0.4 & 0 & 0 & 0.6 \\ 0.6 & 0 & 0 & 0.4 \\ 0 & 0.4 & 0.6 & 0 \end{pmatrix}, p_{ij,2} = \begin{pmatrix} 0 & 0.4 & 0.6 & 0 \\ 0.6 & 0 & 0 & 0.4 \\ 0.4 & 0 & 0 & 0.6 \\ 0 & 0.6 & 0.4 & 0 \end{pmatrix}, \\ p_{ij,3} = \begin{pmatrix} 0.5 & 0 & 0 & 0.5 \\ 0 & 0.5 & 0.5 & 0 \\ 0 & 0.5 & 0.5 & 0 \\ 0.5 & 0 & 0 & 0.5 \end{pmatrix}, p_{ij,4} = \begin{pmatrix} 0.5 & 0 & 0 & 0.5 \\ 0 & 0.5 & 0.5 & 0 \\ 0 & 0.5 & 0.5 & 0 \\ 0.5 & 0 & 0 & 0.5 \end{pmatrix}. \end{cases}$$

Using Equation (7) we get

$$V_4(x)\begin{cases} X_1 = x_1x_2 + x_1x_3 + x_2x_4 + x_3x_4 \\ X_2 = x_1x_2 + x_1x_3 + x_2x_4 + x_3x_4 \\ X_3 = x_1x_4 + x_2x_3 + \frac{{x_1}^2}{2} + \frac{{x_2}^2}{2} + \frac{{x_3}^2}{2} + \frac{{x_4}^2}{2} \\ X_4 = x_1x_4 + x_2x_3 + \frac{{x_1}^2}{2} + \frac{{x_2}^2}{2} + \frac{{x_3}^2}{2} + \frac{{x_4}^2}{2} \end{cases}$$

5. Example 5, operator $V_5(x)$ with $m = 5$: In the case of distributed matrices $p_{ij,k}$, then there are five as

$$p_{ij,k} = \begin{cases} p_{ij,1} = \begin{pmatrix} 0.5 & 0 & 0.9 & 0 & 0 \\ 0 & 0 & 0 & 0.75 & 0.6 \\ 0.1 & 0 & 0 & 0 & 0 \\ 0 & 0.25 & 0 & 0 & 0 \\ 1 & 0.4 & 0 & 0 & 0.5 \end{pmatrix}, p_{ij,2} \\ = \begin{pmatrix} 0 & 0 & 0.1 & 0 & 0 \\ 0 & 0.5 & 0 & 0.25 & 0 \\ 0.9 & 0 & 0.5 & 1 & 0 \\ 0 & 0.75 & 0 & 0 & 0.35 \\ 0 & 0 & 0 & 0.65 & 0 \end{pmatrix}, \\ p_{ij,3} = \begin{pmatrix} 0.5 & 0 & 0 & 0.7 & 0 \\ 0 & 0 & 0.9 & 0 & 0.4 \\ 0 & 0.1 & 0 & 0 & 0.5 \\ 0.3 & 0 & 0 & 0.5 & 0 \\ 0 & 0.6 & 0.5 & 0 & 0 \end{pmatrix}, p_{ij,4} \\ = \begin{pmatrix} 0 & 0.45 & 0 & 0.3 & 1 \\ 0.55 & 0.5 & 0 & 0 & 0 \\ 0 & 0 & 0.5 & 0 & 0.5 \\ 0.7 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.5 & 0 & 0 \end{pmatrix}, \\ p_{ij,5} = \begin{pmatrix} 0 & 0.55 & 0 & 0 & 0 \\ 0.45 & 0 & 0.1 & 0 & 0 \\ 0 & 0.9 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0.5 & 0.65 \\ 0 & 0 & 0 & 0.35 & 0.5 \end{pmatrix}. \end{cases}$$

Using Equation (7) we get

$$(x)\begin{cases} X_1 = x_1x_3 + x_1x_5 + x_2x_4 + x_2x_5 + \frac{{x_1}^2}{2} + \frac{{x_5}^2}{2} \\ X_2 = x_1x_3 + x_2x_4 + x_3x_4 + x_4x_5 + \frac{{x_2}^2}{2} + \frac{{x_3}^2}{2} \\ X_3 = x_1x_4 + x_2x_3 + x_2x_5 + x_3x_5 + \frac{{x_1}^2}{2} + \frac{{x_4}^2}{2} \\ X_4 = x_1x_2 + x_1x_4 + x_1x_5 + x_3x_5 + \frac{{x_2}^2}{2} + \frac{{x_3}^2}{2} \\ X_5 = x_1x_2 + x_2x_3 + x_3x_4 + x_4x_5 + \frac{{x_4}^2}{2} + \frac{{x_5}^2}{2} \end{cases}$$

6. Example 6, operator $V_6(x)$ with $m = 5$:

In the case of distributed matrices $p_{ij,k}$, then there are four as follows

$$p_{ij,k} = \begin{cases} p_{ij,1} = \begin{pmatrix} 0.5 & 0 & 0 & 0.5 & 0 \\ 0 & 0.5 & 0.5 & 0 & 0 \\ 0 & 0.5 & 0 & 0 & 0.5 \\ 0.5 & 0 & 0 & 0.5 & 0 \\ 0 & 0 & 0.5 & 0 & 0.5 \end{pmatrix}, p_{ij,2} \\ = \begin{pmatrix} 0 & 0 & 0.65 & 0 & 0.35 \\ 0 & 0 & 0 & 0.35 & 0.65 \\ 0.35 & 0 & 0 & 0.65 & 0 \\ 0 & 0.65 & 0.35 & 0 & 0 \\ 0.65 & 0.35 & 0 & 0 & 0 \end{pmatrix}, \\ p_{ij,3} = \begin{pmatrix} 0 & 0 & 0.35 & 0 & 0.65 \\ 0 & 0 & 0 & 0.65 & 0.35 \\ 0.65 & 0 & 0 & 0.35 & 0 \\ 0 & 0.35 & 0.65 & 0 & 0 \\ 0.35 & 0.65 & 0 & 0 & 0 \end{pmatrix}, p_{ij,4} \\ = \begin{pmatrix} 0.5 & 0.5 & 0 & 0.5 & 0 \\ 0.5 & 0 & 0.5 & 0 & 0 \\ 0 & 0.5 & 0.5 & 0 & 0 \\ 0.5 & 0 & 0 & 0 & 0.5 \\ 0 & 0 & 0 & 0.5 & 0 \end{pmatrix}, \\ p_{ij,5} = \begin{pmatrix} 0 & 0.5 & 0 & 0 & 0 \\ 0.5 & 0.5 & 0 & 0 & 0 \\ 0 & 0 & 0.5 & 0 & 0.5 \\ 0 & 0 & 0 & 0.5 & 0.5 \\ 0 & 0 & 0.5 & 0.5 & 0.5 \end{pmatrix}. \end{cases}$$

Using Equation (7) we get

$$(x)\begin{cases} X_1 = x_1x_4 + x_2x_3 + x_3x_5 \\ \quad + \frac{{x_1}^2}{2} + \frac{{x_2}^2}{2} + \frac{{x_4}^2}{2} + \frac{{x_5}^2}{2} \\ X_2 = x_1x_3 + x_1x_5 + x_2x_4 + x_2x_5 + x_3x_4 \\ X_3 = x_1x_3 + x_1x_5 + x_2x_4 + x_2x_5 + x_3x_4 \\ X_4 = x_1x_2 + x_1x_4 + x_2x_3 + x_4x_5 \\ \quad + \frac{{x_1}^2}{2} + \frac{{x_3}^2}{2} \\ X_5 = x_1x_2 + x_3x_5 + x_4x_5 + \frac{{x_2}^2}{2} \\ \quad + \frac{{x_3}^2}{2} + \frac{{x_4}^2}{2} + \frac{{x_5}^2}{2} \end{cases}$$

5. Conclusion

In this paper, the new nonlinear model of complementary stochasticity quadratic operators has been established. The sufficient conditions and notations have in turn been defined to investigate the complementary stochasticity quadratic operators. In fact, the less complex structure in this model has been considered.

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SDN Low Latency for Medical Big Data Using Wavelets

Fadia Shah, Jianping Li, Raheel Ahmed Memon
School of Computer Science and Engineering, University of Electronic Science and Technology of China, Chengdu 611731, China
fadiashah13@yahoo.com, jpli2222@uestc.edu.cn , raheelmemon@iba-suk.edu.pk

Abstract

New era is the age of 5G. The network has moved from the simple internet connection towards advanced LTE connections and transmission. The information and communication technology has reshaped telecommunication. For this, among many types of big data, Medical Big Data is one of the most sensitive forms of data. Wavelet is a technical tool to reduce the size of this data to make it available for the user for more time. It is also responsible for low latency and high speed data transmission over the network. The key concern is the Medical Big Data should be accurate and reliable enough so that the recommended treatment should be the concerned one. This paper proposed the scheme to support the concept of data availability without losing crucial information, via Wavelet the Medical Data compression and through SDN supportive architecture by making data availability over the wireless network. Such scheme is in favor of the efficient use of technology for the benefit of human beings in the support of medical treatments.

Keywords: Medical Big Data, Cache, SDN, Wavelets, Compression, Low Latency.

1. Introduction

With every passing day, there is more increase in mobile phones and their applications, smart devices, sensors, automated systems; therefore, the world has become a global village not only for humans but also for machines. The wireless network is modified from connection of devices and web services to the internet of things (IoT). Many IoT [26] devices are working under Medical Big Data support [14, 17]; many health-related applications are developed and are automatically working without human involvement [23]. The smart phone, with a Heterogeneous environment (HetNet) has a number of smart automatic applications. Since there is a remarkable increase in Machine-to-Machine (M2M) communication as well as Human-to-Machine (H2M) communication, this thing makes the Medical Big Data a really very big data. For a proper network traffic the flow of Medical Big Data; and Network traffic engineering [1, 23] for this MBD transmission to the proper destination is very vast research topic in many directions.

In this regard there are the data reliability, maintenance, updating and modification as the key concerns, since Medical history is the most important requirement at any time interval for a proper diagnosis. Medical Big Data is available in many forms like X-Rays, CT scan, MRI, ECG, EEG and many more. This all data is considered for every individual due to the fact that medical related decisions are based upon

this. Missing a single piece of information can mislead the proper treatment. When this data is made available over the internet models, for example the cloud technologies, its reliability is the most important issue; even security is another concern. Just like in developing countries E-Health is a very popular technology. More work is still going on to make these things work smoothly under one platform.

Now a day's more devices are made available online. The automated systems collect information and update it that makes it a huge network traffic and the most useful information to be available for more time. The architecture which supports huge and fast network traffic is Software Define Network (SDN) [5] for 5G technology. It is flexible, job-oriented, supportive and capable to tolerate the high bandwidth utilization. It has two separate planes [1, 2]. Such scheme is suitable for huge number of devices with a variety of operating systems, but all work efficiently under one platform. The high speed network with less time span is very much favourable for the upcoming latest technologies.

In future there will be much more load of medical data over the network for the companies concerned with technical health. In advanced countries, there are organizations working on health data management systems in more refined and sophisticated ways.

The Fig. 1 shows SDN architecture indicating separate levels of SDN for network management by dividing the system into two basic modes. They are connected by an interface. The requests are fulfilled by Controlled Plane. And the data plane focuses only on the information. More and more devices are involved to the network and their efficiency is tried to entertain at the maximum level.

The remaining part of this paper is organized as follows: Section 2 presents the brief introduction of wireless network architecture with SDN and information processing. It also relates the work with advancements made so far in order to increase system efficiency. Section 3 clearly states the problem definition and its importance. Section 4 states the proposed architecture along-with its layout, compatibility and components that emphasize its importance for adaption. Section 5 shows the results and Section 6 is for conclusion and limitations.

2. Background

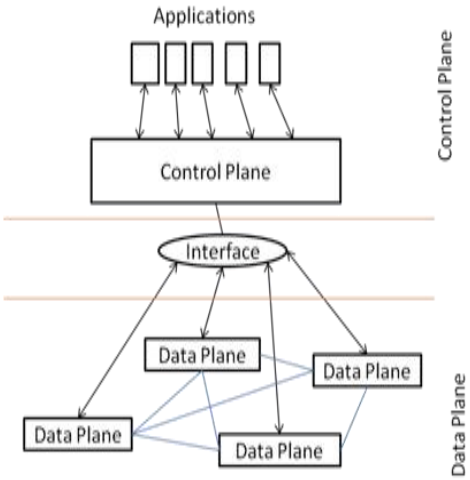


Figure. 1: SDN Architecture Indicating Two Planes

Soon after the discovery of internet and device sharing, cloud technologies became a very interesting and vital topic and area of research. It is still a very informative and innovative concern for new researchers. When it is information over the cloud, the key concern is the data availability and reliability. Precisely, the Medical Big Data availability is the most important concern. Its storage and consultation cannot be maintained manually.

A. Motivation: Big Data is concerned with huge increase in the data and since any information related to medical sciences compels the proper and necessary treatment directions, so its every bit can't be negligible. The cloud mobile network is the hot favourite area of discussion in practical technology lives [7, 11, 20]. For smallest activities, human

beings are being replaced by machines. This thing has many advantages and disadvantages at times; but in any case the concern is to focus on the information saving and utilization schemes. For this big data over wireless network, this concept further improved the management of a huge number of users and originated SDN more popular which redirect control and data plane separately. As a result now we are having tones of data containing the least relevant and proper information. MBD Information is a key concern in diagnosis and the suitable treatment of a patient [20]. The basic purpose is to transfer medical information from the source to destination within a remarkable time, such that there is no missing information and it is useful at both ends. The information communication architectures are now being developed based upon Information Centric Network (ICN) [13, 19], but, unfortunately, the SDN architecture cannot directly support ICN operations. Network Virtualization (NV) [2] and Network Function Virtualization (NFV) extended the utility of network beyond traditional WMN [15, 16]. The ICN are content-based networks that rely data flow from IP to named-based content routing [10]. The SDN Controller [6] can provide the network with programmable functions, such as a load balancer, Network Address Translation (NAT), firewall and special-purpose routing protocol [10]. It is difficult to access MBD all so efficiently and easily with ordinary schemes. So for new network architectures and schemes, network efficiency and reliability is being improved gradually.

B. Related Works: For heavy network traffic, especially wireless network, cache management works efficiently for MBD over Heterogeneous Networks. This is also useful for medical Big Data. Cache is the temporary memory which can store MBD in the form of image and video files from one source to anywhere in the network. The Information Centric Networks structure identifies and is aware of the context of a request. The LTE Radio link [7] connection is strong platform and acts as a backbone but sometimes its reliability is doubtful; thus the cache aware networks [5] ensure content availability.

Network is more effective using SDN via NFV [11] that shares required network functions virtually and globally, extending network utility via MBD content management [10,18]. An Information Centric Network node has two basic functions: a) caching function which caches a data. B) a name-based routing function that routes a user request and its corresponding response based on the name of the data object.

Fig 2. Describes the basic network infrastructure where Evolved Packet Core (EPC) is the core network connection and Long Term Evolution (LTE). Basic Network Infrastructure backbone and radio link LTE is responsible for increasing speed and capacity together with core network. Such infrastructure is very much helpful in MBD transfer via SDN [11] for upcoming technology. MBD from Controller to Base Station (BS) and nodes eNodeB, a variety of devices are receiving the requested MBD.

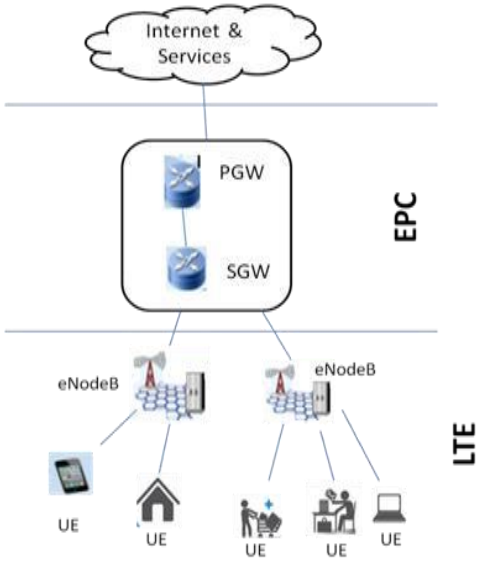


Figure. 2: MBD Storage in Wireless Network

Most of the devices are working on different platforms, hardware and software. The main concern is to entertain every request and maximize the cache hit ratio via Openflow protocols [10] to ensure valuable communications. To share traffic load in tangible time, Coordinating cache [9] share their MBD status with some neighbouring cache. Specific content delivery networks [9].

$$(Effeciency) H_R = 1 - M_R \quad (1)$$

Where H R is the Hit rate and MR is the Miss rate. The equation 1 indicates the efficiency of the medical data related wireless network can be improved if the miss rate is reduced. For load balancing it is most important thing to access MBD smoothly without blocking the network flow. In the past it was the serious problem of redundancy [7, 8] but now instead of replicating data, only the cache status is coordinated, dynamic cache allocation [7], MBD via wavelet.

3. Problem Definition

In this smart world, we are millionaires in data but starving in information. MBD in the form of X-Ray image, MRI, CT scan, ECG and video is stored over wireless network. Information centric network targets information instead of IP address. For this purpose, the system medical data in the form of information must be shared to get the right access. It needs proper storage for further efficient access strategies. The actual problem is to digitize the data and make it available to only the concerned consultant. The patient doesn't need to keep the loads of medical history in the form of manual files; but now to use the advance technology to facilitate healthcare improvement schemes. The actual scheme is cooperative cache that share their status to facilitate network. There are a number of cache schemes implemented to improve the system latency. For example, the increase in size of network cached, implement on-path and off-path cache schemes, distributed cache architecture, coordinating and non-coordinating cache, content popularity and network traffic. Along with these all facilitating network schemes, the concern is which data to store. The network infrastructure is vast and versatile. The main problem is how to store this critical medical big data on wireless network to access it in least latency. To activate more devices and applications over the heavily functional network, conversion of the Information Centric Network to Information Critical Network is the key concern in the proposed system.

4. Architecture

In the proposed system, the coordinating and dedicated cache will support the query fulfilment up to as much maximum level as possible. As the network is enriched with a huge number of cache all over the network, the Medical Big Data is set available at a few nodes but not on all the nodes over the network. The relevant data is made available on some of the cache intelligently. Since, the network Controller has all information of the network, the dedicated cache reduces the Controller load too. The Core network with centralized cache and for Ad-Hoc network coordinated cache. The Medical Big Data can be observed under two schemes. One type of data which utilize more bandwidth over the network like multimedia or video data, such type is the CT scan, MRI, etc. Another type of medical-related data is image file and utilizes low bandwidth like the X-Ray, ECG file, Consultant report, etc.

A. Design Layout and Compatibility: The distinct feature of the wireless network architecture considered in this paper is to reduce latency time by utilizing cache by an intelligent manner. It means to apply the medical data availability on the nearest or early redirected cache. For a popular BS, the number of cache hit rate is more due to the

number of user equipment's as compared to the cache at isolated edge. Make some cache as the dedicated cache for medical data availability; and some cache as the content aware cache.

The size reduction can be done using Wavelets which is an excellent tool to efficiently reduce the size of Medical Big Data in a very reliable manner. It truncates more useless part of the data and makes available the information containing bites. Through this way there is no more huge size of the information and this way the required information can be stored over the network and can be accessed back without utilizing more bandwidth.

The cache architecture is no doubt coordinating and shares data but not every cache is a status-sharing cache. The coordinating cache architecture is quite familiar and very well-known as before. It is emphasized that the neighbouring cache of every high bandwidth utilization data cache is the coordination cache. This reduces the network overload and flexible traffic management. Thus most of the requests are fulfilled thus improving cache hit rate.

B. *Methodology:* The Content Centric Network is not aware of IP addressing to fulfil requests efficiently and effectively. More the miss rate means the poor network efficiency. With normal network traffic with a limited bandwidth, more miss rate will increase load to receive request, time to search the required data and acknowledgements (most of the scenario).

The medical big data digitization will make the data from ordinary and sensitive file to a refined secure digital form. For example, the considered images of X-ray file format are selected. It can be seen that the normal X-ray image represents the current state of a patient. The chest X-ray is showing the lungs condition, the spots at different places and the dental X-ray shows the status of oral cavity and gums. Similarly the skull X-ray also contains the critical information of head region. It is not possible to make such information available all the time, so the advanced way is to make them available over the wireless network, store it in the cache and via SDN making cache coordinating and sharing the status of dedicated cache all over the network when needed.

Ordinary systems make such type of situations end at the system malfunction at any form like deadlock or snail network working.

Table 1: Original and Wavelet Compressed Image Formation

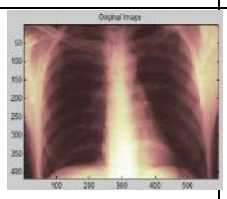
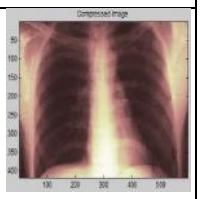
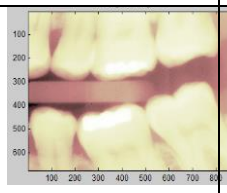
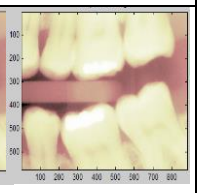
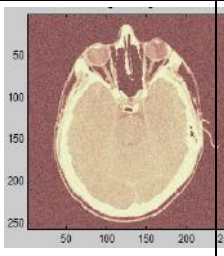
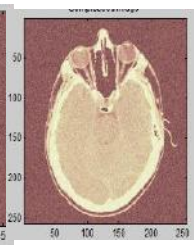
Ser #	Original Image	Compressed Image
1		
2		
3		

Table 1 shows the images before and after the image compression is done by using Wavelets Compression. It can be seen that the image

quality is almost the same as in the original image. The three different types of images were selected and processed and were found almost as the same image. The difference in the images is so negligible that we can rely on the compressed image for decision making. So such type of scheme for compression is applicable on SDN technology. The network for Medical Big Data accessing and functioning efficiency can be observed by the time utilization on average, this can be calculated by:

$$T_{avg} = h\ c + (1-h)\ M \quad (2)$$

Equation 2, where **Tavg** is average time, **h** stands for hit rate, **c** stands for **cache**, **(1-h)** is for miss rate, **M** stands for miss penalty. The requesting device gets the hit ratio for requested image. More the number of devices needs more efficiency to maintain the quality of network utilization. MBD available at any of the network edges, for latest technologies it is being struggled to reduce the latency up to 1ms.

By this type of combination of Medical Big data by Wavelets Compression and this data flow over the network by SDN architecture improves the network cache hit ratio but when the request is not fulfilled, it is redirected to the other destination instead of declaring the failed query response. This ensures least request dropout. It means less miss ratio. The MBD Coordinated Cache in terms of **Euclidian Distance** is a good approach for accessing MBD in a better way to ensure data availability. It is therefore,

$$dist\,(x,y)\,,(a,b) = \sqrt{(x-a)^2 + (y-b)^2} \quad (3)$$

From user equipment to content directed cache, the Euclidian distance including noise can be determined by equation 3. For the proposed system, dedicated cache (where medical wavelet compressed data is residing) is determined at the most busy base stations, determining the more number of hits, the coordinating cache (which share the status and path of medical data cache) will be the average hit rate cache. This coordinating cache will be determined by Euclidian Distance. It will share the status from a remarkable distance from other cache.

5. Results

The wireless network without coordinating cache architecture for Medical Big Data with heavy network shows poor performance and less hit rate. Even if the medical data availability is made possible at different dedicated terminals; involving the Controller to dedicated cache and/or cache, and also the dedicated cache to cache coordination. Requests are thus redirected to only the concerned cache. This will increase system efficiency and improve the system latency time. The systems developing under SDN architecture with cache support are either coordinating cache based or dedicated cache based. But for Medical Big Data using this dedicated, coordinating cache, the latency reduction with proper information access improves the network efficiency. Such system supports the medical smart devices; wavelets ensure the minimization of data loss and data reliability in time and frequency domains. So this scheme is efficient in many aspects when implemented.

The graph determines the change in network performance when we change the number of cache for Medical Big Data availability. This is with general data orientation. It shows here blue line means hit rate for request response hit rate and green line means cache status sharing with neighbouring and it improved the performance. For about 200 cache the system performance is tested.

The system hit rate is increased when the heavy video medical data compressed via Wavelet compression is kept at farther cache and dense and more image Wavelet compressed data is stored near to user equipment. The system is tested in three ways.

Test 1: When there is simple request response from cache assuming performance is 30 percent improved.

Test 2: When the cache redirects request towards SDN controller assuming performance is 55 percent improved.

Test 3: When there is dedicated coordinating cache assuming performance is 75 percent improved.

The increasing in number of cache reduces network load, the coordinating cache further reduces the network load by sharing the status and dedicated distributed coordinating cache not only shares its status but the dedicated cache has the status of sub-net or neighbouring cache. This means dedicated Medical Big Data storage in cache. From equation 2 and 3, applying K- Nearest Neighbour algorithm, the system efficiency is noticeably improved and is represented by the following graph. Here, the blue lines show the best performance due to coordinated cache and easily approachable Medical Big Data for user equipment.

Systems focusing MBD via advance LTE telecommunication systems are most concerned systems. It is tried to develop the systems which are most facilitating for the patient-consultant relationship. It will reduce decision time, towards least complications and improve early diagnosis. In network dedicated coordinated content cache in distributed and wireless network systems is a smart scheme which can improve information retrieval while ensuring quality management. This is the backbone of health-based ideal systems.

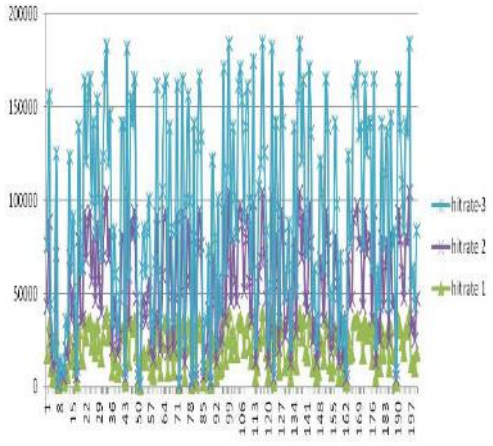


Figure. 3; Medical Big Data for Huge Network Coordinating Cache

6. Conclusion

Wireless Network technologies are improving the quality of life in different ways. The health quality improvement is a basic need for a productive society. For this concern, the medical big data availability from patient report generation to consultant is an important task. Using SDN technology and high speed network bandwidth utilization, the tele-health systems are being developed which the aim to maintain all medical health related all data for a proper diagnosis.

Keeping wireless technology as a backbone, SDN as a service-oriented technology, patient as a data-generating source, the low latency approach by reducing the size of medical data, its availability on distributed, dedicated and coordinating cache will help the treatment technologies in coming days.

7. Limitations and Future Work

The proposed system provides an efficient approach for MBD in network cache systems via distributed coordinating cache scheme. It is efficient to access information via considering low latency and system reliability. However, what data to exactly store, how to maintain data quality and storing more data within a limited cache, is still to be explored.

Acknowledgements

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Increasing the Energy Efficiency of TICK by Selecting Adaptive Forwarding Nodes in Wireless Sensor Networks

Muhammad Ashraf, Muhammad Akram
College of Information and Communication Engineering, Sungkyunkwan University, Suwon 16419, Republic of Korea
ashraf84@skku.edu , akram.khan@skku.edu

Tae Ho Cho
College of Software, Sungkyunkwan University, Suwon 16419, Republic of Korea
thcho@skku.edu

Abstract

Time-Based Dynamic Keying and En Route Filtering (TICK) reduces the communication costs for wireless sensor networks by eliminating the exchange of control keying messages. TICK is more energy-efficient and is good at securing events as they occur; it also selects predetermined forwarding nodes for re-encryption operation without considering their residual energy (RE) which causes more energy depletion. We propose an energy- efficient method that selects forwarding nodes for re-encryption with high energy levels and a low hop count (HC). Simulation results indicate that the proposed method achieves better energy conservation.

Keywords: Wireless sensor networks; SNs; network energy; en route filtering

1. Introduction

Modern technological advancements have led to the development of sensor nodes. Each sensor node has a constrained data processing capability, restricted storage, low-powered resources, and a small communication area. Still, they have the potential to thoroughly monitor a given physical environment. A collection of such nodes is called a sensor network and can be used in various applications, including health, transportation vehicles and intelligent highways [1]. Since sensor nodes are left unattended and are deployed in a hostile environment without any infrastructure, adversaries can easily compromise these nodes [2, 3]. In addition, sensor nodes carry limited and generally irreplaceable power sources. Therefore, providing energy efficiency and resilience against false injected data are the most important factors.

The TICK scheme [4] addresses these issues and minimizes the communication costs. It is also resistant against false information being injected into sensor-based applications via a novel approach. TICK achieves high energy savings by eliminating the exchange of control messages regarding keying or rekeying. We propose a method that efficiently selects forwarding nodes for re-encryption operation by considering the residual energy (RE) of the forwarding nodes, along with their hop count (HC); this

determines which forwarding nodes are more suitable for re-encryption operations in order to reduce the risk of classifying a valid message as malicious and increase the energy efficiency of forwarding nodes.
The proposed method presents the following contributions:

- Reduced false positive classification.
- Improved energy efficiency by selecting en route nodes with high energy level.

The rest of this paper is organized as follows: Section 2 presents related work. A comprehensive description of the proposed method is provided in Section 3. A performance evaluation of the proposed method is discussed in Section 4 and conclusion is presented in Section 5.

2. Related Work

Many en route filtering schemes have been developed that filter malicious data from the wireless sensor networks (WSNs). In Dynamic En route Filtering (DEF) [5], several nodes employ their authentication keys to endorse legitimate reports. Hence, it depletes more energy via authentication and by using separate secret keys. In Statistical En route Filtering (SEF) [6], different keyed Message Authentication Codes (MACs) are used to validate each sensed report. In this way, the size of the reports increases due to the MACs overhead. Although bloom filters are helpful in decreasing the overhead of MACs, they have many flaws implemented in static key management schemes.

The Bandwidth Efficient Cooperative Authentication for Sensor Networks (BECAN) [7] scheme is based on the graph characteristics of node deployment and the cooperative bit-compressed authentication technique. It provides high security by early detection of injected false data in the network but causes extra-overhead at the forwarding nodes and consumes unnecessary energy resources due to the multi-report solution. Selcuk et al. [1] presented a TICK scheme for WSNs that sends reports to the base station without sending rekeying messages. Sensor nodes encrypt each report with a dynamic key generated by their local time values. The working principle of TICK protocol is comprised of three phases. In the first phase, when an event occurs, the source node utilizes its local time variable and generates a one-time dynamic key. The dynamic key is a function of the source node's local time (t_1) and the initialization vector (IV), as shown in equation (1)

$$K_1^t = F(t_1 + IV) \quad (1)$$

The initialization vector is loaded in every node at the time of deployment. The generated one-time dynamic key is then used for security services such as encryption and authentication. Finally, the encrypted report is sent to the upstream forwarding nodes.

Although TICK saves more energy compared to other schemes like DEF, SEF, and BECAN, it selects forwarding nodes for re-encryption ineffectively, causing rapid depletion of the limited energy resources. This strategy is pre-determined that every 3rd, 5th, or 7th forwarding node is selected for the re-encryption operation while trying to maintain the time window bound, as shown in *Fig.1*. The problem with this strategy is that it does not consider the residual energy of en route nodes and the selected forwarding nodes are fixed and dedicated for the re-encryption operation. These selected nodes must continuously perform re-encryption operation, which depletes more energy and may die early.

3. PROPOSED METHOD

A. Overview

The proposed method utilizes the functioning modules of TICK and modifies the crypto (CRYPT) module. The other two types of modules, i.e., time-based key management (TKM) and filtering-forwarding (FFWD) modules, are the same as in equation 1.

B. Crypto (CRYPT) Module

This module obtains the dynamic key generated at the TKM module and performs the required security operations. The key from the TKM module is also verified in this module. If the verified key is not correct, it obtains another key from the TKM and continues this operation until it finds the correct key. Otherwise, it considers the report as malicious and drops it in the FFWD module when all attempts to find the correct key are exhausted within the tick window (TW).

We have considered remaining energy of the node because in each round there will be some energy consumption at each node. So, after processing each round, the remaining energy is considered for the next round. If the RE of the forwarding node is less than the threshold, the node is discarded from session of traversing reports expires. The BS decides which nodes are to be selected for the re-encryption based on two parameters (RE and HC), as shown in *Fig. 2.*

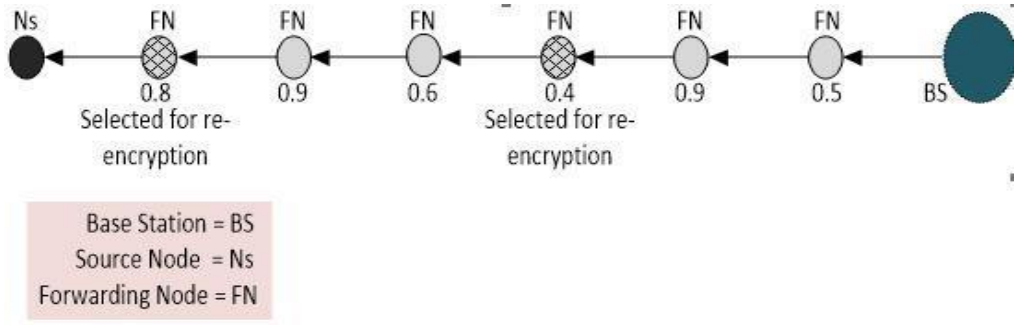

Figure. 1: Selection of Forwarding Nodes in TICK

In our proposed method, we employ a selective re-encryption operation in the CRYPT module, reducing the chances of considering a safe incoming report as malicious and conserving the energy of the forwarding nodes as much as possible. The BS regularly monitors the network status after a consideration for selection for re-encryption in order to extend the battery life of the node.

$$RE = E_{Ni} > TH \quad (2)$$

Selection of the forwarding node for re-encryption is based on its energy state being greater than the threshold:

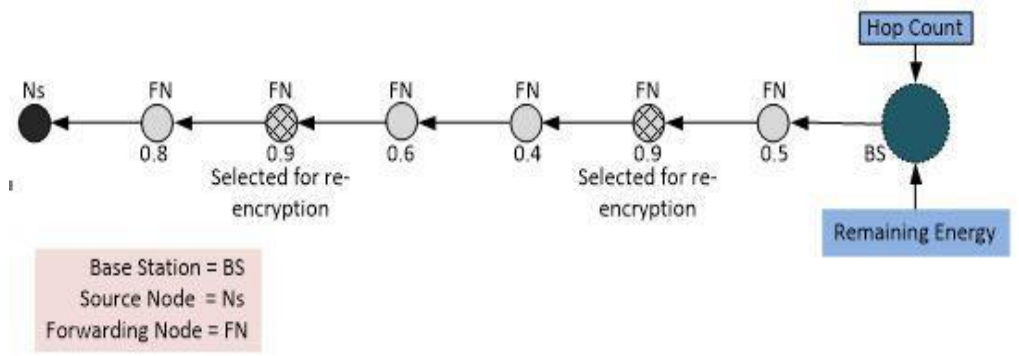

Figure. 2: Selection of Forwarding Nodes in the Proposed Method

Here, E_{Ni} is the current energy of i^{th} node and TH is the threshold.

The hop count (HC) is another vital factor in selecting forwarding nodes for re-encryption. HC in our work is the distance between two sensor nodes that are capable of performing re-encryption. If the distance between two encrypting nodes increases, the safe report

$$HC = d_1 - d_0 < TW \qquad (3)$$

May be dropped by classifying it as a malicious report. Our proposed method considers this factor and selects the forwarding nodes for re-encryption depending on the HC status. If the HC between source node and receipt node is within the time window (T_w), the node is selected for selection for re-encryption, otherwise, the candidate node is discarded from the competition. The HC is computed as:

Here, d_1 is distance of candidate en route node, d_0 is the distance of source node and TW is the time window.

4. Performance Evaluation

A. Simulation Parameters and Assumptions.We have simulated the proposed method in a custom simulator developed in Microsoft Visual C ++ 2010. Network details and parameters are presented in Table 1.

The network is composed of a BS and 500 sensor nodes; the nodes are randomly deployed in a field of size 100 m × 100 m. The BS is located at the edge of the network and knows the sensor nodes' IDs and their location information in advance. The sensor network used in our method is shown in *Fig.3.* Each sensor node has a fixed and limited sensing range and is battery powered with a fixed limited energy of 50 mJ. In order to achieve an energy efficient network, it is essential to consider the residual energy of all candidate nodes in order to select the forwarding node. This helps improve the energy efficiency by selecting the number of participating nodes with high energy levels.

Table 1: Simulation Parameters

Parameter	***Value***	***Parameter***	***Value***
No. of nodes	100	E_{ini}	50 mj
Network size	100 * 100 m^2	E_{rx}	66.7 µj
BS location	0 * 0 m^2	E_{tx}	59.6 µj
Link rate	250 kbps	E_{sens}	9.0 µj
Range	30 m	E_{enc}	3.3 µj
Report size	28 Byte	E_{dec}	3.3 µj
Tick window	16	E_{mac}	8.6 µj
Time offset	U [-3, +3] µs		

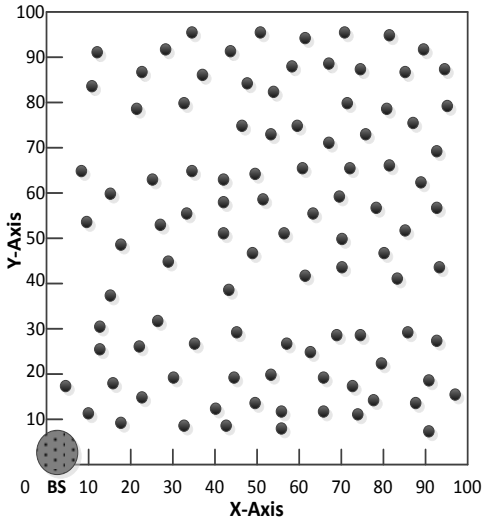

Figure. 3: Random Deployment of Sensor Nodes in the Network

A. Simulation Results

The source node generates reports and sends these reports to the BS. The proposed method achieves high energy savings compared to the target method, and *Fig. 4*

shows the energy consumption of selected forwarding (re-encrypting) nodes versus the number of rounds. This shows that the proposed method efficiently selects dynamic forwarding nodes for the re-encryption operation by considering the two main factors (REL and HC). However, this is not the case in the target method, where the forwarding nodes for re-encryption are pre-decided. These nodes have to perform the re-encryption operation continuously, and, in turn, they will consume more energy as the number of data rounds increases.

As selected forwarding nodes are pre-decided based on each 3rd node strategy in the target method, and does not consider the residual energy of en route nodes. So, the selected forwarding nodes will deplete more energy, as they have to continuously perform re-encryption and may eventually die. Some reports generated by the source node do not reach the BS, as some of the forwarding nodes die earlier due to continuously performing the re-encryption operation; this information cut-off point is reached earlier in the target method than for the proposed method. Hence the proposed method extends the network lifetime. The number of depleted nodes is shown in Fig. 5.

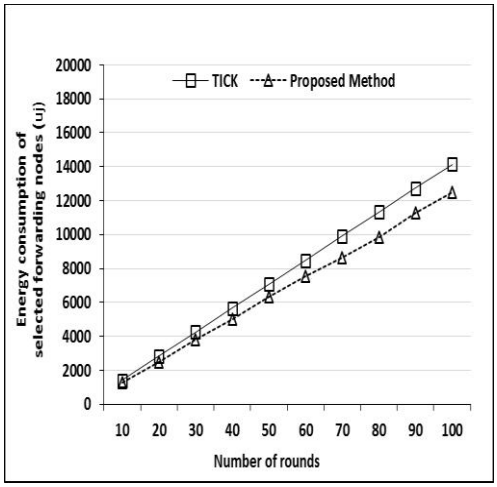

Figure. 5: Energy Consumption for Forwarding Nodes (μj) Versus Number of Rounds

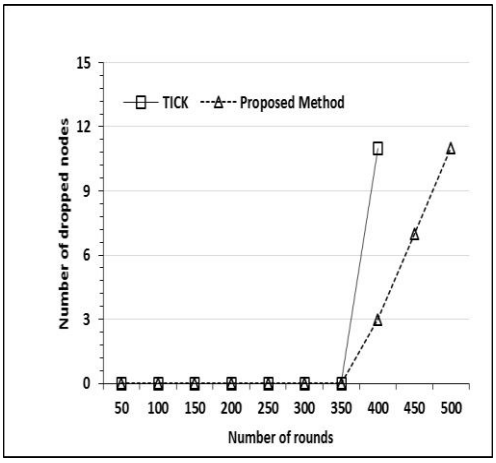

Figure. 4: Network Lifetime

5. Conclusion

Time-Based Dynamic Keying and En Route Filtering (TICK) provides network security and minimizes the communication cost. This is accomplished by eliminating control keying messages that cause depletion of a large amount of energy for each event sensing and forwarding node. Although this method is more energy-efficient and performs well in securing events as they occur, it allocates pre-decided selective nodes for re-encryption, which consumes more energy because it does not consider network parameters (such as the remaining energy of the filtering nodes, and the distance between two encrypting nodes). In order to address these issues, we proposed an energy-efficient method that helps select forwarding nodes for the re-encryption operation based on two network factors: the remaining energy of the forwarding nodes and the hop count. The proposed method improves energy conservation and extends the network lifetime. The simulation results validate the effectiveness and efficacy of the proposed method.

Acknowledgments

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Human Brain inspired Artificial Intelligence & Developmental Robotics: A Review

Suresh Kumar
Aberystwyth University, UK
Sukkur Institute of Business Administration, Pakistan
suk9@aber.ac.uk

Patricia Sha
Aberystwyth University, UK
phs@aber.ac.uk

Abstract

Along with the developments in the field of the robotics, fascinating contributions and developments can be seen in the field of Artificial intelligence (AI). In this paper we will discuss about the developments is the field of artificial intelligence focusing learning algorithms inspired from the field of Biology, particularly large scale brain simulations, and developmental Psychology. We will focus on the emergence of the Developmental robotics and its significance in the field of AI.

Keywords: Artificial Intelligence, Development & Robotics

1. Introduction

Human kind has been trying to improve life make this world more useful for centuries. We have seen evidence where humans tried to make tools from the wood and rocks to use them for acquiring food and keeping safe themselves. In modern era, we can see researchers in the different fields are working to improve human life. Researchers in the field of medical science are trying extend and quality of life. On the other hand technologists are trying to make human life easier. In modern are we are still developing tools to keep human life safe and easier.

Humans invented mechanical tools to make their jobs easier. These tool used to be operated by the human or under the commands provided by humans directly. Robots are those kind of mechanical tools which were invented to help human in their jobs are work in such environments where it is dangerous or difficult for humans to work. In short, machines and tools were invented to make human life easier and work quicker. Moreover robots are not supposed to get bored with repetition of tasks and don't get tired like humans do.

We can see different kind of robots, from humanoid [1]–[3] to animal like [4], [5]. However, the word "Robot" was first introduced in the stage play in 1920 where a human played roll of a machine which looked and behaved like humans do [6]. This play can be assumed a human thought about future where humanoids machines to be seen acting, thinking, even look like humans. Almost 90 years later of that stage where term robot was

introduced initially, another play was staged in which a robot played roll of human [7]. The robot in this play was controlled manually by human which discards this machine, Geminoid, from the basic definition robot, an automated machine [8]. Even though robot in this play was not automatic yet it fulfils most of predictions made in the 1920's play. In 1950, Walter developed to mobile robots, which were automatic and moved at free will [9]. Today, many machines satisfies the definition for the term "Robot". However, humanoid seems to be most suitable machines for this term.

Initially, AI and robotics community focused on single purpose intelligence and robots. Rule based systems were the initial approach for AI systems. Now trends are being shifted toward general purpose intelligence and robotics [10]. Human body have more than 200 joints and about 244 degree of freedom (DoF), controlled by more than 600 muscles [11]. Such a large DoF helps human to manipulate different objects and perform different movements. The equipment, objects, tools, etc. in this world are designed in this world to be used by humans. To be helped by the machines, researchers design robots to manipulate objects as humans do. That is why trends in robotics design is shifting towards humanoid robots.

In this paper, we will discuss about the emergence of "Artificial Intelligence" inspired from developmental psychology and its implementation in robotics. In section II we will discuss about the early concepts of intelligence and artificial intelligence. In section III, some AI approaches inspired from the human brain will be discussed and in section IV we will present an introduction of developmental psychology in robotics and some related projects. Finally, in the section V we will make a conclusion about the two inspirations, biology (Human brain) & psychology, in the field of artificial intelligence.

2. Intelligence & Artificial Intelligence

We, modern human beings, were named as "Homo sapiens" which means "Wise man" [12]. Humans have capability of thinking, reasoning, recognition, acting, learning and behaviours. Neisser believes that "Intelligence" of one is a degree by which it can be compared to a typical intelligent subject [13]. Intelligence or intelligent can be defined in various ways depending upon the culture, status and language. The Word "Intelligence" originates from Latin word engender, which means generate [14]. This gives the idea that word intelligence means to generate information. Although word intelligence has no clear scientific definition but can be defined various ways. Honavar believes that intelligence is collection of various attributes such as perception, reasoning, adaption and learning, autonomy, creativity and organisation [15].

Focusing these aspects in robots, Asimov proposed three general laws for the robot [16], described as under:

- Robot should not harm human being and not allow them harm themselves.
- Robot should follow the instruction provided by human beings, except if the instruction conflicts with first law.
- Robot should protect itself, as long as it does not conflicts with first two laws.

A robot following the Asimov's laws must possess capability of acting automatically and ability to perceive human actions. To be acting automatically in this world and ability to perceive human actions, a robot must possess intelligence like humans do. Although many of the commercial machines, from home appliances to motor vehicles, are claimed to be intelligent, however those lack in very general intelligence. Field of "Artificial Intelligence" (AI) was emerged as a field of robotics to introduce intelligence in the robots. Nilsson relates terms such as perception, reasoning,

adaption and learning, autonomy, creativity and organisation, possessed by human beings with artificial intelligence as well [17]. He believe, an artificial system is said to be intelligent if it possess the capability of perception, reasoning, action, autonomy, organisation and adaption and learning. In broad sense, goal of AI is to develop machines which can think and act as humans do.

In 1956, first conference was held on artificial intelligence [18]. It was anticipated that soon machine may be replaced with human beings for different tasks which are dangerous or boring for the humans. Initially, focus of AI researcher was to develop machine to reason only rather than to reason and act. That is why initial focus was on top-down approach of intelligence machines, focusing reasoning and thoughts in machines [19]. This is why, initial theory about the artificial intelligence was that it is study of information processing for problems [20].

3. Human Brain Inspired Ai Models

Bio-inspired artificial learning systems are very popular in AI since the beginning of AI. AI researcher focusing on this approach, try to simulate human like processing in machines. In human psychology it was believed that heart is central part of thinking and reasoning. In 1664 a book on human brain, "Anatomy of the Brain", was published by English physician, which describes brain responsible for the mental functions [21]. Working of the human brain was studied by the biologists for further explanation about the human thinking. In 19th century biologists proposed two different theories about brain functions. One theory considers brain cells work all together for mental tasks, while other theory, Neuron theory, considers brains cells working independently for mental tasks. In later research it became clear that brain works in small networks of neurons and different parts of brain response to specific tasks [21]. A neuron consist of nucleus, cell body, axon and dendrites. Neurons receive signals from other neurons via dendrites and pass to other via axons and synapse. A typical neural structure is shown in figure 1.

In late 20th century, robotics started to replicate human brain process, particularly neural processes. Artificial neural networks

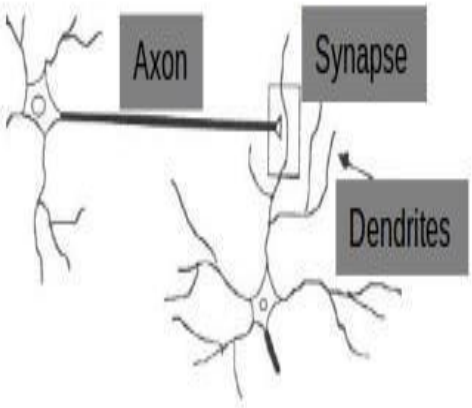

Figure. 1: Neuron Structure [22]

(ANN) are part of such efforts. ANN are structures of interconnected units, neurons, implemented mostly in software but are possible to implement in hardware as well. Each unit in the ANN emits a signal to all connected units when it is activated. Activation occurs when input signal to the unit is greater than the threshold. It is believed that ANN represent processing in biological system, human brain. A generic ANN architecture is shown figure 2. Learning in AI is adapted by changing network architecture and weights of the network connections [23]. There are three main learning paradigms; supervised, unsupervised and hybrid. But there are certain limitations in the ANN as well, like learning pattern should be defined, weights changed accordingly and information to be accessed by is to be defined.

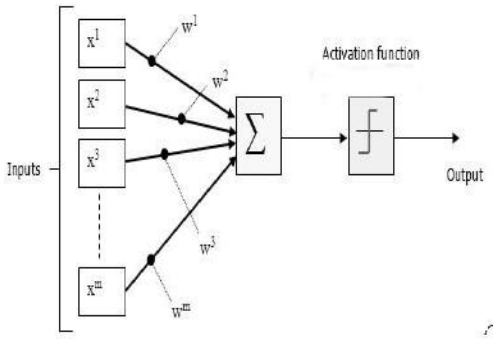

Figure. 2: A Typical ANN Architecture

ANNs are very popular among robotics and AI research community due to remarkable characteristics such as learning, noise tolerance and generalisation [24]. ANN are also provide parallel processing within the system. ANN consist of network(s) containing small processing units. Which resembles the networks of neurons in the brain, hence called artificial neural network.

ANN are now being used in wide range of robotic and other computational models. ANN are seems to be very useful when learning involves single task or a predefined environment. ANN systems are trained in the environment to perform the task provided and task is learned. ANN network are very fast due to parallel processes in the network, however the learning (training) takes longer and more computation. These network do not seems very reliable when environmental conditions are changed from the one it is trained.

Apart from ANN there are other efforts as well in the field of AI, some of them are still in progress. These are biologically inspired artificial brain architectures. Following the developments in neural science and considering "Brain as the seat of mid" researchers started to develop simulation of human brain processing for machines. Garis et al. in [18] describe these architectures as large scale brain simulations. Blue Brain project is the part of biologically inspired research, in which researcher are trying to simulate the neural processing in human brain. Supported by IBM, researcher are trying to develop simulation of cerebral cortex using super computer [18]. Project involves reconstruction of multilevel processing of neuron layers and synapse. This project, as assumed, will be able to simulate the processing of any part of the human brain if specific information provided.

Another project on reverse engineering was initiated in 2008 along with Blue brain project, system of Neuromorphic Adaptive Plastic Scalable Electronics SyNAPSE. The name of the project is taken from the inter neural conjunctions, synapse. Goal of this project is to produce brain like intelligent computer, however the intelligence will be comparable to small mammals, cats and mice. Neurogrid, project of Stanford researcher, is another approach to design the simulation of neural activity [25]. It is a hardware project which simulates neural activity of one million neurons having six billion synapse. Super computer using Neurogrid model is rival of the Blue brain project as this system consume very less power as compared to Blue brain computer.

Brain Based Devices (BBD) are another approach to neutrally control robotic devices. Fleischer use robotic devices not just to control using neural activity but also test the hypothesis about neural mechanism for the behaviours [26]. Their idea strongly supports the behavioural learning. BBD robots interact with the world autonomously without any prior instructions. BBD robots of this projects categorises signals received from the sensors attached, without prior information, and learns actions which produce such sensory information.

Even though Bio-inspired brain simulation projects are of great importance in the field of AI and have produced interesting results, however these projects still lacked in human like learning and not very cost effective [27]. However such projects seems

to be very useful to understand the neural processing of sensory information perception building.

4. Psychology & Robotics

We have seen significant developments in different domains of AI, such as pattern recognition, image processing, control systems and reasoning games. In some cases such machines can perform better than humans, however all of these developments in AI cannot be compared to general human intelligence as the main goal of the AI is to create human like intelligence in machines.

In bio-inspired robotics application, researchers mostly attempt(ed) to replicate neural processing in human brain. Whereas human brain is very complex and it is very difficult to understand and reconstruct neural activities of the human brain with our current and limited technology. In developmental psychology it is believed that intelligence is adapted from interaction with the environment in which human grows [28]. Research from psychology who believe this idea of intelligence in human consider humans as blank slate when born and knowledge is developed over the course of entire life.

Though the idea, about humans as blank slate at birth, is supported by a group of developmental psychologists but still widely used in developmental psychology and robotics. Another group of researchers believes that humans have innate knowledge to deal the world situations at birth [29]. This "Nature vs. Nurture" debate is classical and still researchers from both groups doing research to support their theory.

In this review we are focusing Nurture side of the "Nature vs. Nurture" debate and consider intelligence as hierarchical developed while acting in the environment rather than innate. Thus we will consider robotics models in which learning is hierarchical developed rather than built-in. As sensory information in our environment is contained in hierarchical architecture and most of the initial AI systems were not able deal to deal with this kind of sensory information hence were not able to create hierarchical learning [27]. To build a human like intelligent, artificial intelligent system need to be evolved like so, discussed in section 1. This is the main purpose of the field Developmental robotics. Although, the idea of such field, cognitive developmental robotics, was appeared long ago [30] but it was formally emerged in 2000 [31]. Developmental or cognitive robotics is branch of robotics in which agent learns its capabilities rather than hard-wired in it already. Thus learning is neither task-oriented not domain specific, unlike ANN.

Embodiment is very important in developmental robotics. The term "Embodiment" refers to the physical presence of the system not just a software or simulation. Such a system should be able to perceive the environment with the sensors provided and interact with the body, may be end effector(s).

Thus artificial intelligent system in developmental robotics develops intelligence with (artificial) brain and body. There are different researchers around the world, working on different projects on developmental robotics with different platforms, such as iCub, NAO, ASIMO, COG, CASPER etc. This community of research has shown interesting results using these platforms. A brief descriptions of some of those projects is given here.

- Schlesinger used reinforced learning, with the back-propagation and Qlearning, model to investigate the Baillargeons study [32] about causality perception [33]. In the experiment young infants were habituated to causal event, car moving behind an occluder. He found that infants, 6 months old, looked longer impossible events than possible events. In Schlesinger's model habituation stage was replaced with the training phase. Schlesingers finding concludes that the

eye tracking is disturbed by unusual event that may be the reason that infants look longer on impossible events.

- iTalk, another developmental approach for robotics, was aimed to achieve conceptualization, action development and social emergence with the cognition building. This project was more emphasising the social aspect of learning, imitation [34]. Implementing lingual learning capabilities in iCub, significant achievements were observed.

Research was also focused on how verbal communication in infants helps to learn constructive knowledge. Project has produced more than 100 papers.

- IM-CLeVeR project one of the recent projects on the developmental learning using humanoid platform, iCub. The objectives of this projects are; learning mechanism for abstracting sensorimotor information and learn new skill with the intrinsic motivations and reusing these skills [35]. Project is about developing learning system having capability of intrinsic motivation to interact with environment and learn. Models for Object tracking, saccading, and reach development are of significant outcomes of this project. Project proposed bio-constrained models for both of these developments, saccade and reach. Models are inspired from the developmental stages of the infants. Models were integrated with the machine learning algorithms with capability of vision perception and abstraction [36], [37].
- Experience, another intrinsically motivated learning based project. Learning is based on the interaction and exploration of the surrounding and creating representation of the world. Computational models were implemented on humanoid robot, iCub, and achieved significant results [38]. Project focuses on high level representation of object and outcomes resulted with acting on those objects. Object Action Complexes (OAC) system was developed in this project [39]. OAC system recorders learning in high level representations and uses those to interact with novel situations in the environment. System is also capable of planning actions for given environmental state. Moreover, OAcs can also be generalised, that makes system to learn and act irrespective of environment.
- CHILD, a developmental learning approach in which learning takes place with the continual process. Learning paradigm is ANN supervised reinforced [40], combination of Q learning and temporal transition hierarchies, with no knowledge at the beginning. System creates knowledge units while acting on the environment continuously. Key aims of the project are; continual task independent learning based on the sensory information and learning new skills and reusing them. But the system has limitation for the states of particular sequence. Although system shows effective and fast learning in Maze problem [40], however its learning is environment dependent.
- GRASP project is an attempt to design cognitive grasp capability based on novel situations. Researchers aimed to develop a cognitive system which can act, grasping and manipulation, in the environment and learn. The acquired knowledge will be used to plan the strategy for grasping new objects. Learning grasping and affordance

of human will be the base of this model. Robot will decide optimum degree of freedom (DoF) for the task.

- MoDeL (Modeling Developmental Learning) is one of the recent projects related to developmental robotics. Purpose of this project is develop learning model for humanoid robot inspired from infants' developments, biological/physical and cognitive. Project is inspired from the autonomous learning in infants while playing with object in surrounding. Researchers in this project aimed to develop autonomous, intrinsic motivated play behaviour in artificial agents to learn physics of the environment.

5. Conclusion

Although AI is more than half century old but we don't have machines with human like general intelligence yet. There are two main reason for this; not enough developments in the field of neuroscience to understand human brain processing and inadequate technology to process information as fast as human brains do. Earlier researchers from AI focused on human brain and biology to mimic human brain like intelligence. In last decade, researcher also focused on developmental psychology for understanding human intelligence. Also embodied agents were used in the researches rather than just simulation. This is widely accepted in robotics community that AI system needs bo embodied and act in the environment to learn and build intelligence [31], [41].

Developmental psychology deals with the physical development of human body, language acquisition and cognition over lifespan. In humans learns and develop knowledge about surrounding over the life span. Human body, with different sensors, have limited capabilities and develops over time. Like human vision develops over earlier months of life [21]. Similarly poor muscles and muscle control limits infants to sit, stand and walk. This makes humans to perform and perceive with certain constraints and with the time, and learning, these constraints are removed and make human to develop knowledge hierarchical.

We believe that to develop a human like intelligence, an artificial intelligence should possess body, to act, cognitive capability, to learn, and constrained system, resembling humans, to learn and build hierarchical knowledge. Also large scale brain simulation will help to further understand the human brain and information processing within it.

We conclude that the field, Developmental robotics, provides a new directions for psychologist to explore the learning process in human beings and will assist robotists to build human like learning AI and robotics. The field will help psychologists to test their hypothesis about learning and cognitive development in humans, particularly infants and children, which otherwise will take long process of planning and experiments with subjects with matching criteria. For example to study about infant vision and object reaching will cost psychologists huge amount of time for planning, designing and conducting experiments. Similar Experiment can be easily performed on robot with just minute changes in the vision parameters in the robotic system.

In this context developmental robotics studies provides two main purposes, developing brain like intelligence in artificial agents inspired from developmental (psychology) theories and testing such theories on artificial agents to feedback. Thus field will help to explore high level learning in human brain. Whereas large scale brain simulations will help to understand the neural level understanding about learning and knowledge building.

In this paper, we aimed to focus origin of human brain like intelligence and its current development with two different research strategies. In continuation with this

paper series, our next work we will focus on particular example of learning in AI inspired by infants play.

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Enhancing the Statistical Filtering Scheme to Detect False Negative Attacks in Sensor Networks

Muhammad Akram, Muhammad Ashraf,
College of Information and Communication Engineering, Sungkyunkwan University, Suwon 16419, Republic of Korea
akram.khan@skku.edu, ashraf84@skku.edu

Tae Ho Cho
College of Software, Sungkyunkwan University, Suwon 16419, Republic of Korea
thcho@skku.edu

Abstract

In this paper, we present a technique that detects both false positive and false negative attacks in statistical filtering-based wireless sensor networks. In statistical filtering scheme, legitimate reports are repeatedly verified en route before they reach the base station, which causes heavy energy consumption. While the original statistical filtering scheme detects only false reports, our proposed method promises to detect both attacks.

Keywords: WSNs; SEF; en route filtering; false positive attack; false negative attack; energy efficiency.

1. Introduction

Wireless Sensor Networks (WSNs) comprise tiny nodes equipped with restricted computational resources and limited energy supply. WSNs are usually deployed in an exposed environment which increases their proneness to security compromises such as cryptographic information capture [1]. Compromised nodes are exploited by attackers to initiate numerous attacks, such as denial of service, sinkhole attack, and eavesdropping [2]. Usually, attackers use compromised nodes to create bogus event reports, and inject them into the network to drain the energy of the network [1, 2]. Various filtering schemes have been proposed to detect and filter these bogus reports en route [1-5].

Compromised sensor nodes can also be exploited to block authentic data from being delivered to the base station (BS), by attaching false Message authentication codes (MACs) to legitimate reports [1, 2, 6]. These true reports with false MACs attached to them are dropped en route at the intermediate verification nodes. PVFS counters these two attacks simultaneously, whereas other filtering schemes only focus on countering the false report injection [FRI] attack, which is also known as the false positive attack [1-8]. All of these filtering schemes use either static or dynamic authentication key sharing [1-5, 7, 8].

We propose to enhance the filtering capacity of the SEF scheme so that it not only filters false reports, but also allows legitimate reports with false MACs to reach the BS station without failure. The probabilistic

voting-based filtering scheme (PVFS) [2] is a static scheme that deals with both the attacks, and filters false reports at the probabilistically chosen verification nodes. In statistical en route filtering (SEF), each intermediate node verifies the report probabilistically, and if it detects an invalid MAC attached to it, it immediately drops it. SEF exploits network scale and density to drop false data through the collective detection power of several intermediate relay nodes. However, while making a decision to drop the report, SEF does not allow the forwarding nodes to consider the results of the previous verifications. Every intermediate node that finds an invalid MAC makes an independent decision to drop the report. This inflexibility of SEF allows room for the compromised nodes to impact the performance of the network. Compromised nodes launch a false negative attack by attaching false MACs to the legitimate reports that are dropped en route by the verification nodes. The false negative attack stalls the passage of true reports to the BS [1, 2, 6]. By appending a few extra bits in the header of the report being forwarded, we can make SEF restrict false negative attacks. Once a threshold for the verification of true reports is reached, they are marked safe, and forwarded without further verification.

The FRI attack aims to drain the energy resource of the sensor network, and render it useless in the presence of compromised nodes. The detection probability in SEF increases with distance. However, relying on the filtering capability of filtering nodes farther from the report generating cluster and closer to the BS leads to an uneven load share. An energy-hole syndrome appears in which the filtering nodes around the BS soon die out on account of their rapid depletion of energy and unceasing verification activity. The energy-hole phenomenon causes information lose and shortened network lifetime.

In SEF, each forwarded report is verified against T MACs created by keys from T distinct non-overlapping sub-pools of authentication keys. Firstly, each intermediate node checks if a report carries T MACs, as well as T key indices from T different partitions. Secondly, the intermediate node tries to check if a key's index in the report matches that of one of its own keys. If so, the intermediate node tries to authenticate the report by calculating a new MAC with the same key. If the new calculated MAC matches the MAC contained in the report, the report is authenticated, and forwarded. If the MAC is found to be false, the report is immediately dropped. If none of the key indices in the report matches a key index of the keys possessed by the node itself, an intermediate node simply forwards the report. Thus if it possesses the matching key, every intermediate node is virtually required to authenticate the report. None of the intermediate nodes considers the outcome of the previous verifications performed by the earlier nodes in the decision making. If a single MAC is found to be false, any intermediate node immediately drops the report. This is why the SEF schemes do not handle the false negative attack, as well as it incurs more energy by requiring every intermediate node to verify the report.

2. Statistical En route Filtering (SEF)

SEF is the first scheme that was proposed to filter false data injected by adversaries exploiting compromised nodes. In SEF, a pre-generated global key pool of size N, maintained at the BS, is divided into multiple non-overlapping n partitions, each of size m, i.e.

$$N = m \times n$$

Figure 1 shows the partitions of the global key pool and allocation of k keys to each sensor node in the network. Every key is mapped against a unique key index for identification purpose during the process of en route filtering. Prior to sensor deployment,

each node is preloaded with k (k<m) keys, along with their key indices from a single partition.

When an event occurs, neighbouring nodes prepare the reports and broadcast them. The broadcasted report is of the form: {LE,TS, E}, in which LE indicates the event occurrence location, TS is the event time-stamp, and E indicates the type of event. If a node finds that the difference between the broadcast values and its observed values are within the predefined error boundary, then the broadcast values are accepted. The node whose broadcast values are accepted by more nodes is elected as the Center of Stimulus (CoS) node. CoS is responsible for preparing a final report endorsed by T MACs attached to it. After the selection of the CoS, every detecting node A selects one key Ki from the pool of keys it possesses and generates a MAC.

$$MAC_i = f(K_i, Report)$$

Where, Report is of the form {LE||Ts||E}, and f(n,m) computes a MAC of the message m using key n. The node forwards {i, MACi}, the key index, and the MAC to the CoS. All the {i, MACi}'s tuples are collected by the CoS from the detecting nodes, and classified according to the key partitions. MACs created by the keys from the same partition belong to the same category. CoS randomly selects a single tuple {i, MACi} from each of T(T≤n) categories, and attaches them to the report. The final report forwarded towards the BS looks like:

$$\{L_E, T_s, E, i_1, MAC_{i1}, i_2, MAC_{i2}, \dots, i_T, MAC_{iT}\}.$$

each forwarded report carries exactly T key indices and T MACs. Reports carrying more or less than T key indices and T MACs are dropped en route. Reports that contain more than one key index and MACs from the same partition are also dropped en route.

Since each node is preloaded with a set of randomly chosen keys from a randomly selected partition of the global key pool, it is predicted to possess a key with certain probability that is used to generate one of the T MACs attached to the report. That key is used to verify the authenticity of the report.

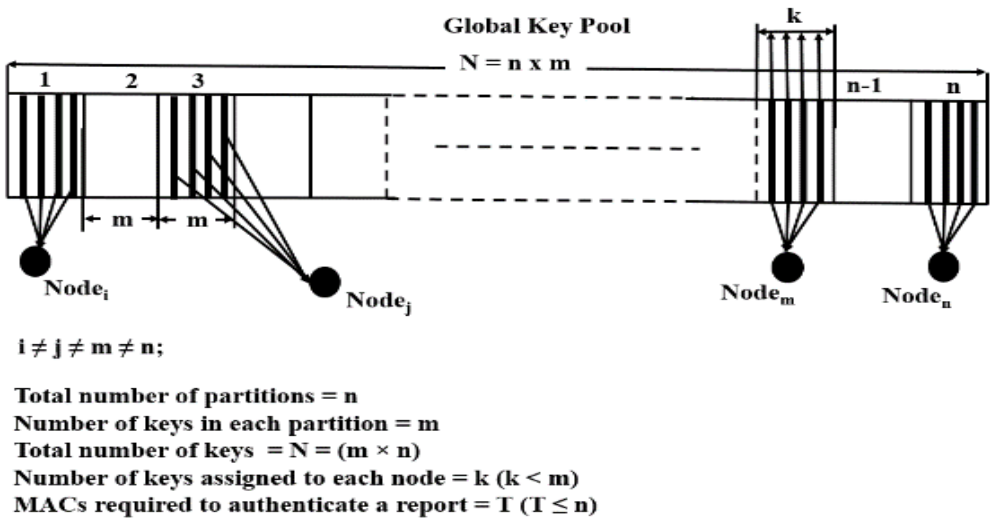

Figure. 1: Global Key pool, Its Partition and Allocation of Keys to Individual Nodes.

3. False Negative Attack Detection in (SEF)

The robustness of SEF against FRI attack is solely based on the fact that a compromised node can possess keys from only one category. In order to produce a counterfeit report, the compromised node is still required to forge the remaining T-1 MACs. This is why SEF provides a strong protection against the FRIA attack and becomes an ideal choice among the filtering schemes.

However, SEF suffers from a serious weakness when it comes to protection against a false negative attack viz. a False MAC injection (FMI) attack. SEF doesn't consider an FMI attack: neither does it provide a means to safeguard against FMI attack. Compromised nodes are exploited to launch an FMI attack which causes the dropping of legitimate reports.

We propose to include a few more bits in the report header, at the expense of a little energy-per-bit, to achieve greater security against FMI attack. Our proposed method also helps to save a significant amount of energy, by relieving nodes around BS from the verification of legitimate reports. Relieving nodes around the BS from the task of verification avoids energy-hole syndrome and increases network lifetime.

A. Proposed Methodology: When CoS finalizes the report, it also appends two extra fields Verf and Vert, and a flag bit Accepted. Verf records the number of verified false MACs, while Vert records the number of verified true MACs. Once we include these two fields in the header, the intermediate verification nodes will no longer drop the report when finding a single false MAC attached to it. If Vert reaches its threshold, the verification node marks the report safe, sets the corresponding flag bit Accepted to 1, and forwards the report. If the verification node finds that Verf has reached its threshold, it immediately drops the report and informs the BS about its decision. The length of the two fields depends on the length of T. Notice that even though the remaining MACs may be false after Vert has reached its threshold, there is still no need to verify the report further, as the majority of the MACs are true. Every node, Ni, shares a symmetric key KNi, BS with the BS. Using its symmetric key, the intermediate verification node creates a signature of its verification and sends it along with a report to the BS. Now the report that is forwarded to the BS looks like:

$$\left\{L_E, T_s, E, \{(i_s, MACs)\}, Ver_f, Ver_t, Accepted, \{Sig \leq T\}\right\}.$$

Where

$$\{(i_s, MACs)\} = \{i_1, MAC_{i1}, i_2, MAC_{i2}, \dots, i_T, MAC_{iT}\}$$

The inclusion of a few extra bits provides higher security against the false negative attack, and consumes very little energy. Algorithm 1 shows the verification process of the report at an intermediate node Nk.

Algorithm 1.

```
1:  N_k: Intermediate node
2:  Report = N_k.receive({L_E, T_s, E, {(i_s, MACs)}, Ver_f, Ver_t, Accepted, {Sig ≤ T}})
3:  if Report.Accepted = 1 then
4:      Forward Report, EXIT;
5:  end if
6:  if {(i, MAC_i) and (j, MAC_j)} ∈ Report.({(i_s, MACs)}) and i = j then
7:      Drop Report, EXIT
8:  end if
9:  For each i in T (i, MAC_i) tuples in Report.({(i_s, MACs)})
10:     if N_k stores (j, key_j) such that i = j then
11:         if MAC_i = f(Key_j, Report) then
12:             Report.Ver_f := Report.Ver_f +1;
13:             if Report.Ver_t = 3 then
14:                 set Accepted := 1;
15:             end if
16:         else if MAC_i ≠ f(Key_j, Report) then
17:             Report.Ver_f := Report.Ver_f +1;
18:                 if Report.verf = 2 then
19:                     Drop report, EXIT;
20:                 end if
21:         end if
22:     end if
23: end for
24: Forward report, EXIT;
```

As soon as the value of Verf reaches 2, the report is immediately dropped whereas when

the value of Vert reaches 3, the report is marked safe and forwarded to the BS, without further en route verifications.

4. Simulation Results

We have performed simulations to verify the efficiency of our proposed method against the FMI attack. We assume a network comprising 400 sensor nodes uniformly distributed across a field of size 200×40 m2. Simulations are carried out in a custom simulator developed in Microsoft Visual C++ 2012. The hops between the source node and the BS are varied. Reports are generated by the source every 2 seconds. A global key pool of 1000 keys is divided into 10 partitions with 100 keys in each partition. Each node is equipped with 70 keys. Each report and MAC is 36 and 4 bytes in size, respectively. It takes 15 μJ to generate a MAC, 75 μJ to verify a report, and 16.25 μJ and 12.5μJ to transmit and receive a byte, respectively. The threshold values of Verf and Vert are set to 2 and 3, respectively, for T = 5. As soon as the value of Vert reaches 3, the Flag bit Accepted is set to 1, and no more verifications are required.

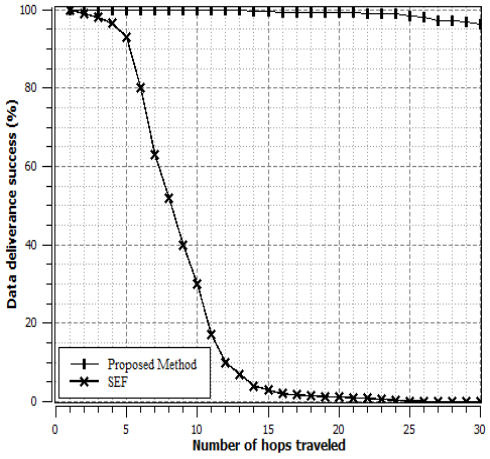

Figure 2: Comparative Analysis of Report Delivering SEF and the Proposed Method, in the Presence of False Negative Attacks.

Figure 2 shows that legitimate reports are delivered to the BS with higher success rate in our proposed method than in SEF. The delivery of legitimate reports is low, solely because after being detected with a false MAC attached to them they are dropped immediately.

5. Conclusion

FRI and FMI attacks are two major attacks that can happen to sensor networks. While SEF provides an excellent safeguard against the former, it leaves room for the latter to badly impact the network's information delivery capability. By appending a few extra bits in the report, we can make SEF to reject false negative attacks. The inclusion of a few extra bits provides higher security against the false negative attack, while consuming very little energy in transmitting them along with the report.

Acknowledgments

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A Fast Implementation of Minimum Spanning Tree Method and Applying it to Kruskal's and Prim's Algorithms

Badri Munier, Muhammad Aleem, Muhammad Arshad Islam, Muhammad Azhar Iqbal
Department of Computer Science, Capital University of Science and Technology, Islamabad
badar_lucky83@yahoo.com, aleem@cust.edu.pk, arshad.islam@cust.edu.pk, azhar@cust.edu.pk

Waqar Mehmood
Department of Computer Science, COMSATS Institute of Information Technology, Wah Cantt
drwaqar@ciitwah.edu.pk

Abstract

In last decade, application developers attained improved performances by merely employing the machines based on higher-clocked processors. However, in 2003 multi-core processors emerged and eradicated the old processor manufacturing technology based on increasing processor's clock frequencies. After emergence of new parallel processor architectures, serial applications must be re-engineered into parallel versions to exploit the computing power of the existing hardware. In this paper, we present an efficient parallel implementation of minimum spanning tree algorithm to take advantage of the computing power of multi-core machines. Computer network routing, civil infrastructure planning and cluster analysis are typically use-cases of spanning tree problem. The experimental results show that the proposed algorithm is scalable for different machine and graph sizes. The methodology is simple and can easily be implemented using different shared-memory parallel programming models.

Keywords: Graph, Minimum spanning tree, Performance analysis, OpenMP.

1. Introduction

Today, multi-core processors have emerged as a viable source of processing power. The introduction of multi-core architecture was due to the power consumption and heat dissipation problems associated with high-clocked single-core processors [1]. A multi-core processor consists of several processing units known as cores [2]. On single core-processors, most of the applications were developed using sequential execution model. Applications executed on new processor architectures suffer performance degradations due to the stall in processor's clock frequencies. To exploit the processing power of the underlying multi-cores, applications need to be re-engineered and parallelised [3]. Computer network routing, civil infrastructure planning

and cluster analysis are typical use-cases of spanning tree problem. A spanning tree can be defined as a subset of Graph G, where all the vertices are covered with minimum possible number of edges. Basic properties of a spanning tree are that it is in the form of a connected graph and does not contain any cycles. A Minimum Spanning Tree (MST) [4] connects vertices of a weighted graph such that the total weight is minimum. In this paper, we discuss the two famous MST algorithms known as Kruskal's [5] and Prim's [6] [7] algorithms. Major contributions of the paper are the development and benchmarking of parallel implementations of Kruskal's and Prim's algorithms. Moreover, we have evaluated the attained performance results using low-level hardware performance counters.

Kruskal's [5] and Prim's [6] [7] algorithms are the two basic techniques to solve the minimum spanning tree problem. An MST represents a sub-graph of an undirected graph such that the sub-graph spans (includes) all graph nodes, is connected, is acyclic, and has minimum total edge-weight. Both the Prim's and Kruskal's algorithms utilize undirected weighted graphs. Prim's and Kruskal's algorithms are considered as greedy algorithms and produce optimal solutions for the MST problem. Prim's algorithm is similar to Dijkstra's algorithm [8]; however, it records previous edge-weights instead of path lengths.

In this work, we present a shared memory-based parallel implementations of Kruskal's [5] and Prim's [6] [7] algorithms. To program shared memory parallel machines, two most-often-used methods are 1) hand-coded parallel threads and 2) using serial code with compiler directives. Writing parallel program is a difficult task, especially if one is required to hand-code the parallel threads. To program shared memory parallel machines, today OpenMP [9] is the most widely used framework for parallelization of the serial code. All threading models typically involve a large overhead related to task parallelization and execution [10] [11]. OpenMP compared to threading method induces less parallelization and execution overhead [12]. Thread-pool model of OpenMP results in significantly less overhead during execution of a parallel program [13]. This paper presents an analysis and study of the parallel MST (Prim's and Kruskal's) programs executed using classical multi-threaded and OpenMP-based execution models.

The rest of the paper is organized as follows: Section II presents the work related to parallelization of Prim's and Kruskal's algorithms. Section III discusses working of the Prim's and Kruskal's MST algorithms. Section IV looks at detailed insight of parallelization of these algorithms. Section V presents the experimental results and the low-level performance analysis of the parallel executions. Section VI concludes the paper.

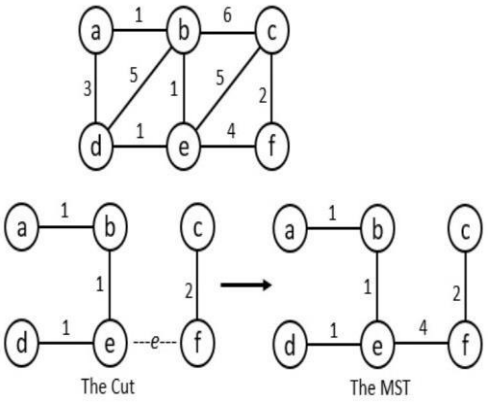


Figure 1: Cut property of MST

2. Related Work

Authors in [14] have proposed a parallel Prim's algorithm implementation on symmetric multiprocessors using cut property of an MST. The cut property can be defined as for any cut C in a graph, if the weight of an edge of cut C is strictly lesser than the weights

of all others edges in the cut C, only then this edge belongs to all MSTs in the graph. Figure 1 shows the CUT property of MST. Suppose, S = (a, b, c, d, e, f) Figure 1 shows the CUT property of MST. Different parallel tasks may initiate separate sub-trees simultaneously and then after merging these sub-trees, the final an MST is formed. Suppose, S = (a, b, c, d, e, f) a parallel task starts developing its tree by selecting the smallest weighted edge (a, b) in the portion of the graph assigned to it. Edges (b, e) and (d, e) also have the smallest weights with no circular paths, and are so included in the tree. Another parallel task starts from a different vertex (f) to form its part of the tree and finds edge (c, f) as the smallest of the assigned edges to this task. Now, for both the parallel tasks the next smallest weighted edge is (e, f) (and has no cycle.) At this point, both the tasks merge their sub-trees to build the final MST.

Another parallel implementation of Prim's algorithm is proposed in [14]. The authors experimented using shred memory multi-processor machines. The presented parallel implementation arbitrarily selects a vertex and keeps it as the root-vertex. Each thread starts a distinct parallel tree. The threads have the ability to conduct asynchronous signals. In the meantime, when crash occurs, one of the threads sends signals to other executing threads using a merge tree operation. In the end, the first thread (thread-0) will have the calculated MST. Authors in [14] employed a load-balanced thread scheduling to reduce make-span of the application.

In [15], authors proposed an efficient parallel implementation of Kruskal's algorithm. The proposed implementation employed helper-thread technique. Kruskal's algorithm is known for showing characteristically sequential features, because it strictly examines all the edges whether they are part of the minimum spanning forest [16] graph or not. However, parallel characteristics of Kruskal's algorithm was exploited using helper threads which check each edge having maximum weight for the cycle. An edge is rejected if a cycle is found. The main thread only checks those edges which are not discarded by helper threads. Using the main and helper thread mechanism the proposed technique avoids any blocking or non-blocking synchronization.

In [17], authors proposed a new approach to speed-up the minimum spanning forest algorithm. The accelerated performance was achieved by employing cache optimization and reduced synchronization overhead. The reduced random memory access behaviour resulted in improved speed-up of Bor˚uvka-based implementation.
Authors in [18] proposed a fast solution to the MST problem based on Bor˚uvka algorithm.

The proposed platform-independent implementation can be executed using multicore CPUs or GPUs. The authors [18] introduced a new and effective technique to perform a contraction of the graph. The contracted graph is obtained by merging vertices into super-vertices. To optimize data-locality, the authors employed compressed sparse row format to build the contracted graph. Their implemented version achieved linear scalability up to 8 threads.

Another approach presented in [19] analyses two algorithms: Shiloach-Vishkin and Hirschberg-Chandra-Sarwate. Authors proposed a new parallel-randomized algorithm for calculating an MST. They employed a randomized greedy approach for the implementation. The employed greedy approach allows one processor to arbitrarily access another processor for work stealing if it finishes its assigned task earlier.

Compared to the helper-threading scheme mentioned in [14] and other techniques discussed in this section, our proposed parallelization technique is simpler and easily implementable. We create threads at runtime that reduces the cost of computation, (as compared to 14]).

3. Minimum Spanning Tree Methods

Prim's and Kruskal's algorithms are two well-known and most-used techniques used for the solution of a minimum spanning tree problem. Below sections present the detailed description of these algorithms.

A. Prim's Algorithm**:** Prim's is a memory-bound algorithm and its performance largely depends on the memory accesses pattern and memory organization [9]. After input is provided, Prim's algorithm starts with an arbitrary vertex (let's say vertex B in our example, see Figure 2) in the graph and marks it as visited. In the next step, the algorithm considers all the edges connected to this vertex (for example edges (B, A), (B, C) and (B, F)), finds the minimum weighted-edge (B, A) among them and adds its weight to the MST. The vertex on the other side connected to this minimum weighted-edge (vertex A) is now the visited one. Now all of the edges connected to this vertex are considered and the minimum one is selected and added to the MST if it does not form a circle. In this way, all the vertices connected by the minimum weighted acyclic edges are found, that form the MST.

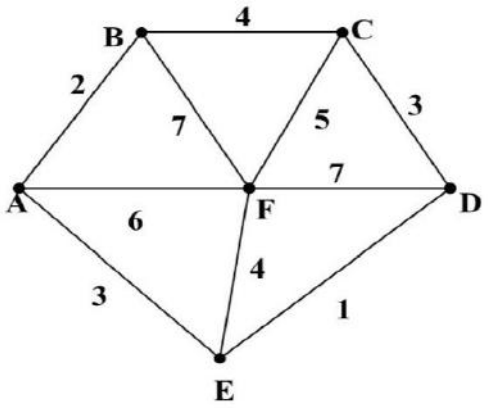


Figure 2: Example: An Undirected Weighted Graph

B. Kruskal's Algorithm: Kruskal's algorithm is based on a greedy approach and is known for exhibiting inherently sequential characteristics. Kruskal's algorithm strictly examines the edges whether they are part of the minimum spanning forest or not [16]. Kruskal's algorithm sorts all edges in ascending order of their weights. It starts adding the minimum weighted-edges to the MST (edges not forming a cycle).

A typical implementation of the Kruskal's algorithm starts with input from the user for the number of vertices and related weights for each edge of the graph. After reading all the edges, the program starts to find a minimum cost edge in the graph (1 less than the total vertices to avoid a loop). The minimum spanning tree is provided as output to the user, showing all the edges that generate a part of the MST. Vertices that do not have edges between them are indicated with 0 values in Table I.

Table 1: An Example Adjacency Matrix (for Figure 2)

	A	B	C	D	E	F
A	0	2	0	0	3	6
B	2	0	4	0	0	7
C	0	4	0	3	0	5
D	0	0	3	0	1	7
E	3	0	3	1	0	4
F	6	7	5	7	4	0

4. Parallelization of Kruskal's and Prim's Algorithms

For parallelization of both the Kruskal's and Prim's algorithms, we employed a divide-and-conquer technique [20]. First, we divide the adjacency matrix into four equal parts considering both the rows and columns of the matrix. Figure 3 shows an example of symmetric matrix having 8 rows and 8 columns. The matrix can be divided into four parts: A, B, C, and D as shown in Figure 3. Figure 3 shows that the matrix partitions B

and C are the same and symmetric. Both of these partitions contain exactly the same set of edges. Any one of these two partitions (B or C) is enough to represent the graph. Therefore, we only employ three parts of the matrix (i.e., A, B, and D) for parallelization. As we have only three parts of the adjacency matrix to compute, we use the number of threads as a multiple of three. The strategy of using the part of the matrix reduces the computational cost considerably and results in improved performance. Each of the three selected parts of the matrix can be computed using a single or multiple computing threads. Each computing thread computes and finds a minimum weighted-edge within the assigned matrix part and returns its cost to the main program. After receiving all the minimum costs (for lower cost edges), the main program selects an edge with the lowest cost. After that, the lowest-cost edge is checked for a cycle in the graph and a cycle-free edge is added to the MST. The correctness of both the serial and parallel versions are ensured by comparing the produced results.

A. Kruskal's Parallelization

The proposed parallelization of the Kruskal's algorithms is performed using the following steps:

Step-1: Partition the input N × N adjacency matrix of a graph G into 4 equal fragments as shown in Figure 2. As we assume that input is an undirected simple graph, fragments B and C are symmetric and same. Using this strategy, we have to compute only 3 parts of the matrix, which reduces the overall computational cost of the parallel version;

Step-2: Using p = 3× i threads are created to compute an MST T by employing the 3 partitions i.e., ith threads for each partition. Each thread sorts the matrix representing the edge weights. In case of more employed processors, one matrix part can be computed using multiple threads;

Step-3: Tree generation is initiated by iterating over the sorted edge-list obtained in step 2;

Step-4: An edge (u, v) is inserted into the MST; if it does not create cycles, i.e., (u, v) ∪ T ⇐⇒ T' does not contain cycles;

Step-5: Step 4 is repeated till node Count (G) ≠ node Count (T).

B. Prim's Parallelization

The proposed parallelization of the Prim's algorithms is performed using the following steps:

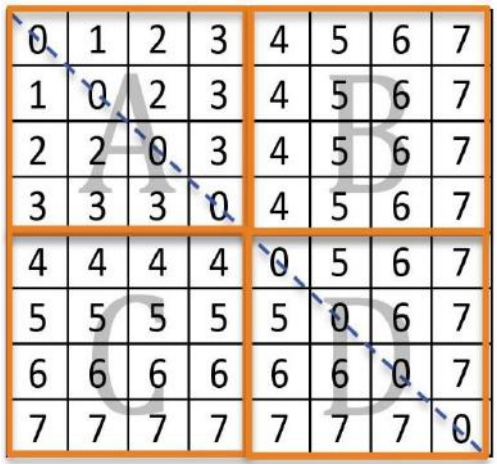


Figure 3: Division of a Symmetric Matrix

Step-1: Partitioning approach for Prim's implementation is similar to the Kruskal's implementation presented in this work. Following are the detailed steps for the parallelization of Prim's algorithm;

Step-2: p = (3 × i) +1 threads are created to compute the MST T from the 3 partitions, i.e., ith threads for each partition. In case of more employed processors, one matrix part can be computed using multiple threads. The additional thread, i.e., main thread, is employed to coordinate among the rest of the threads;

Step-3: Every thread pi where i≤n finds minimum weight edge ei within a row of the adjacency matrix;

Step-4: Every thread pi sends its unmarked minimum ei edge to the main thread. The main thread identifies the global

minimum edge from the received edges emin, adds it to the MST and broadcasts it to all other threads;

Step-5: A computing thread marks corresponding vertices connected by emin as belonging to the MST and updates their assigned part of row i.e. Steps 4 and 5 are repeated till node Count(G) ≠ node Count(T).

5. Results and Discussion

A. Experimental Setup: For experimentations, we employ two nodes or multi-core machines, N1 and N2 parts of our computational cluster. The N1 multicore machine is based on quad-core Intel Q6600 2.4Ghz processor with 8MBs of L2 cache memory. The second multicore machine named N2 was based on Intel core i5-4460 quad-core processor. The processor has a clock speed of 3.2 GHz with turbo-boost option up to 3.4 GHz clock-rate. The processor has a shared L3 cache of size 6 MBs. The implementation of the serial version was done in C++ programming language. The parallel versions were implemented using a threading library of C++ and an industry standard for shared memory parallel programming called OpenMP [13], [21]. Six different graph sizes were used for the experimentation i.e., 256, 512, 1024, 2048, 4096, and 8192 node graphs (having density of 0.87). The parallel versions were evaluated up to 12 parallel tasks on the shared machine. To understand the achieved performances, we measure low-level hardware performance counters [22]. Hardware performance counters are employed for originating micro-architecture level execution profiles. Some of the employed low-level performance counters are L1 data loads, L1 cache misses, last-level cache loads, last-level cache misses, time-elapsed, etc.

B. Kruskal's Results: Figure 4 shows the experimental results of the Kruskal's algorithm. The experimental results conducted on N1 multicore node are shown in Figure 4(a). Larger (graph and machine-size) experiments were conducted on N2 multi-core machine are shown in Figures 4(b) and 4(c). As shown in Figure 4(a), we can observe that the execution time of the Kruskal's parallel implementation (based on 3 parallel tasks) has reduced significantly. The parallel version was implemented using C++ multi-threaded API (named as POSIX execution) and consumes 44.28% less execution time for graph of 256 nodes. For the graph with 512 nodes, the multithreaded implementation performs 13.63% better in terms of execution speed compared to the serial version of the kruskal's implementation. For the largest problem size (graph of 1024 nodes), the parallel implementation achieves 69.14% less execution time. The OpenMP based parallel implementation of the Kruskal's algorithm scales better than the POSIX based parallel implementation (as shown in Figure 4(a)). The parallel version implemented using OpenMP API consumes 46.78% less time for graph size 256. For the graph (with 512 nodes), the OpenMP based implementation performs 5.5× better compared to the serial implementation.

For the largest problem size (graph of 1024 nodes), the OpenMP based parallel implementation achieves 23.27 times less execution time. Figure 4(b) shows the Kruskal's parallel implementation using a C++ based multi-threaded API. The experiment was conducted using 3, 6, 9, and 12 parallel threads. For this experiment, we employ different graph sizes i.e., 256, 512, 1024, 2048, 4096, and 8192 node graphs. The multi-threaded executions based on 3−12 threads show exceptional scalability of the proposed parallel technique of the Kruskal's algorithm.

Figure 4(c) shows execution results of multi-threaded andOpenMP based parallel executions. For this experiment, 256, 512, 1024, 2048, 4096, and 8192 node graphs were employed and executed using 6 parallel tasks (using both the C++ multi-threaded and OpenMP based frameworks). As shown in Figure 4(c), our proposed parallel implementation of Kruskal's algorithm

achieves commendable scalability for all graph sizes (256−8192). The implementation is more scalable for large graph sizes i.e., 4096 and 8192 node graphs (as shown in Figure 4(c)). This experiment shows that the OpenMP based implementation achieves more improved performance compared to the multi-threaded execution. The better performance by the openMP based implementation is due to the decreased threading overhead (because of a thread-pool mechanism of OpenMP).

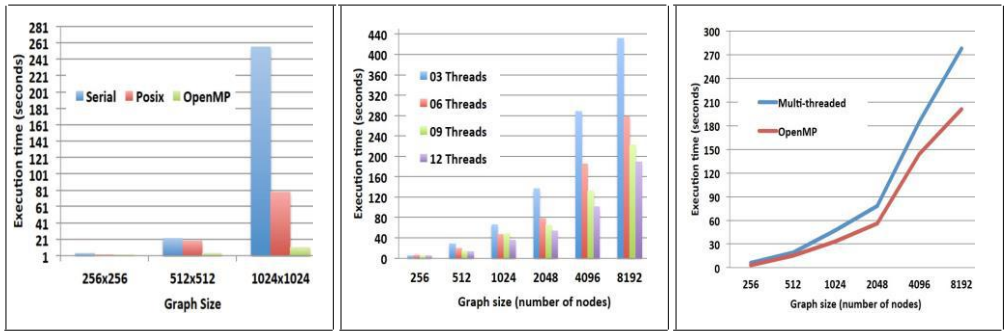
C. Prim's Results: Figure 5 shows the experimental results of the Prims' algorithm. The experimental results conducted on N1 multicore node are shown in Figure 5(a). Larger graph and machine size based experiments were conducted on N2 machine and are shown in Figures 5(b) and 5(c).

Figure 5(a) shows that the execution time of the Prim's parallel implementation is significantly low compared to the serial implementation of the algorithm. The multi-threaded parallel implementation of the algorithm consumes 40% less time for graph of 256 nodes. For the graph of 512 nodes, the multi-threaded implementation performs 23.8% better compared to the serial

Fig. 4: Kruskal's algorithm - experimental results.

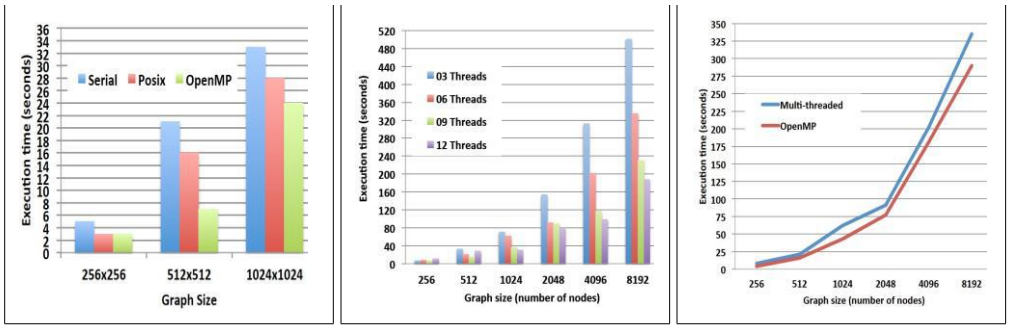
Fig. 5: Prim's algorithm - experimental results.

For 1024 node graph, the parallel multi-threaded implementation achieves 15.15% less execution time compared to the serial implementation. Figure 5(a) also shows the performance results of the OpenMP based implementation of the algorithm. The OpenMP based execution consumes 40% less



(a) N machine experimental results. (b) N Machine Experimental results. (c) N machine - multi-threaded Vs OpenMP.

Figure 4: Kruskal's Algorithm - Experimental Results



(a) N machine experimental (b) N machine experimental (c) N machine - multi-threaded Vs

Figure 5: Prim's Algorithm - Experimental Results

time for graph of 256 nodes. For 512 node graph, the OpenMP based implementation performs 3× better compared to the serial version. For the larger graph (1024 nodes), the parallel implementation achieves 1.37 times less execution time.

Table 2: Kruskal's implementations' low-level Performance Analysis

	Serial			Multithreaded			OpenMP		
Performance counters	*256 nodes*	*512 nodes*	*1024 nodes*	*256 nodes*	*512 nodes*	*1024 nodes*	*256 nodes*	*512 nodes*	*1024 nodes*
No. of CPU cycles	2550233452	39818270014	652615519559	1225112224	23408276714	341509347854	12214224	1022973169	8029365182
L1 data-cache loads	2199128419	35058609247	561047070359	1155064705	19876509874	153996428170	111674550	794648337	6279366872
L1 data-cache misses	15917106	249300967	3945057932	9956063	3498763878	66515064422	1762553	10790167	64280045
LLC loads	661923	11235435	16617373	340998	23265474	3739063543	197900	687764	3582605
LLC misses	11355	259374	138899705	10712	144532	97793415	487	16964	2947696

Table 3: Prim's implementations' low-level performance analysis

	Serial			Multithreaded			OpenMP		
Performance counters	*256 nodes*	*512 nodes*	*1024 nodes*	*256 nodes*	*512 nodes*	*1024 nodes*	*256 nodes*	*512 nodes*	*1024 nodes*
No. of CPU cycles	5517409479	44170709396	66642638011	3301760455	22661017146	43610912012	1543821	5604780	545739760
L1 data-cache loads	4819302587	39015321739	56326775764	2936709114	21134584300	453697918997	6568269	51345678	211792733
L1 data-cache misses	34615034	272096926	401966873	44054498	191687472	373591788	71398	556911	811626
LLC loads	11841706	1011789	17006177	19548411	70108890	136209720	28153	112614	450456
LLC misses	2211	34332	13425386	139283	748083	1879709	6541	14247	171236

Figure 5(b) shows the Prims' parallel implementation using a C++ based multi-threaded API. The experiment was conducted using 3, 6, 9, and 12 parallel threads and different graph sizes i.e., 256, 512, 1024, 2048, 4096, and 8192 node graphs. The multi-threaded executions based on 3−12 threads show excellent scalability of the proposed parallel technique of the Prims' algorithm.

Figure 5(c) shows execution results of multi-threaded and OpenMP based parallel executions. For this experiment, 256, 512, 1024, 2048, 4096, and 8192 node graphs were Employed and executed using 6 parallel tasks (using both the C++ multi-threaded and OpenMP based frameworks). As shown in Figure 5(c), our proposed parallel implementation of Prims' algorithm achieves excellent scalability for all graph sizes (256−8192). The implementation is more scalable for large graph sizes i.e., 4096 and 8192 node graphs (as shown in Figure 5(c)). This experiment shows that the OpenMP based implementation achieves more improved performance compared to the multi-threaded execution. Due to the OpenMP's thread-pool mechanism, less threading-overhead results in improved performances for the OpenMP based executions.

Tables II and III show measurements of the low-level hardware performance counters. We can observe several consistent trends in both tables. In the majority cases, the OpenMP based executions observe lower number of cache loads and cache misses (approximately 10.3% less compared to the multi-threaded execution). The low number of cache misses result in on average better performance of the OpenMP based implementations.

6. Conclusions and Future Work

In this paper, we proposed and evaluated performance of parallel MST methods (Kruskal's and Prim's algorithms). The proposed parallel algorithms were evaluated for their scalability by employing different graph and machine sizes. The experiments showed that the Kruskal's achieves 23× better results in terms of execution time compared to the serial version of the algorithm. For the prim's algorithm, we attained up to 3× better performances compared to the serial version of the algorithm. Moreover, the OpenMP based implementations of both algorithms showed excellent performance and scalability compared to the simple multi-threaded based implementations. Our future work includes large-scale experiments on compute Clouds such as Amazon EC2 and Microsoft Azure platforms.

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A Study of Wearable Bio-Sensor Technologies and Applications in Healthcare

Amir Mehmood,
Department of Computer Science and IT, Federal Urdu University of Arts, Science and Technology, Pakistan
aamir.mehmood@fuuast.edu.pk

Adnan Nadeem
Department of Computer Science and IT, Federal Urdu University of Arts, Science and Technology, Pakistan & Faculty of Computer Science and Information System, Islamic University of Madinah, Kingdom of Saudi Arabia
adnan.nadeem@fuuast.edu.pk

Kashif Rizwan
Department of Computer Science and IT, Federal Urdu University of Arts, Science and Technology, Pakistan & Department of Computer Science, University of Karachi, Pakistan
kashifrizwan@fuuast.edu.pk

Nadeem Mahmood
Department of Computer Science, University of Karachi, Pakistan
nmahmood@uok.edu.pk

Ahmad Waqas
Department of Computer Science, Sukkur IBA, Sindh, Pakistan
ahmad.waqas@iba-suk.edu.pk

Abstract:

In today's world the rapid advancements in Micro-Electromechanical Systems (MEMS) and Nano technology have improved almost all the aspects of daily life routine with the help of different smart devices such as smart phones, compact electronic devices etc. The prime example of these emerging developments is the development of wireless sensors for healthcare procedures. One kind of these sensors is wearable bio-sensors. In this paper, the technologies of two types of bio-sensors (ECG, EMG) are investigated and also compared with traditional ECG, EMG equipment. We have taken SHIMMERTM wireless sensor platform as an example of wearable biosensors technology. We have investigated the systems developed for

analysis techniques with SHIMMERTM ECG and EMG wearable bio-sensors and these bio-sensors are used in continuous remote monitoring. For example, applications in continuous health monitoring of elderly people, critical chronic patients and Fitness & Fatigue observations. Nevertheless, early fall detection in older adults and weak patients, treatment efficacy assessment. This study not only provides the basic concepts of wearable wireless bio-sensors networks (WBSN), but also provides basic knowledge of different sensor platforms available for patient's remote monitoring. Also various healthcare applications by using bio-sensors are discussed and in last comparison with traditional ECG and EMG is presented.

Keywords: Wireless Bio-sensors platforms, ECG, EMG, WBSN & its Applications, SHIMMER^{TM}

1. Introduction

Technological advancements in microelectromechanical systems (MEMS) and very large scale integration (VLSI) elevate the field of sensors into more prominent field for research. Therefore the field of wireless sensors is attracting more and more attention from researchers because of its wide range of applications. It has applications in battlefield, sports, agriculture, fitness, structural monitoring, traffic control, underground mining and healthcare. Actually sensors are devices which not only gather the information about the physical property of an object but also gather the changes that occur in the state of that object. These wireless sensors play a key role in healthcare. The sensors used in healthcare have wide range of applications like, remote patient monitoring, rehabilitation process, ambient assistive living and for biofeedback. Most of the sensors used in healthcare are either implanted inside or placed on the human body. The network of these sensors is called Wireless Body area Sensor Network (WBSN). The WBSN comprises of the sensor nodes (wearable or implanted inside the human body), the sink node (also called coordinator) refers to a mobile phone or PDA (Personal Digital Assistant) or relay node and the base station.

The examples of sensors used in WBSN are, implanted cardioverter defibrillators (ICDs), swallowed camera pills, wearable electrocardiography (ECG), electromyography (EMG), electroencephalogram (EEG), blood pressure (BP), Saturation of Peripheral Oxygen (SPO_2), temperature monitoring sensors, these are the example of physiological sensors or bio-sensors. There are some other types of sensors also used in WBSN, which are inertial based sensors such as accelerometer, gyro meter, magnetometer etc.

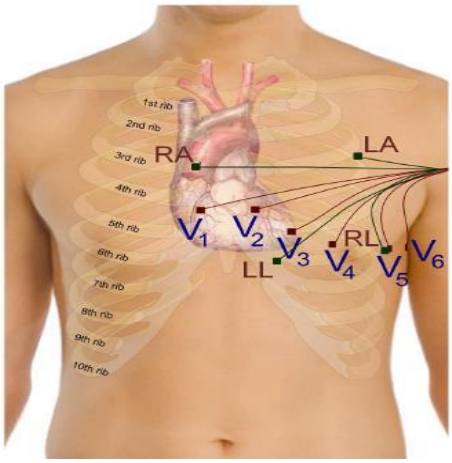

Figure. 1: ECG Electrode Placement Positions [1]

Here in this study, the basic introduction of two bio-sensors (ECG, EMG) is presented. The main reason behind the selection of ECG and EMG is the applications of these two devices in healthcare. The idea behind this study is to investigate different ECG and

EMG wireless platforms and how it will affect the field of healthcare. ECG and EMG are used to identify the causes behind chronicle diseases such as heart attacks, muscle dysfunction etc.

Electrocardiography (ECG) is the process of capturing the tiny electrical activity of a heart detected through electrodes for a defined time period. These electrodes are placed on the surface of body. ECG is used to detect the disruption in pattern of electrical activity.

A graph comprises of the peak (refers to voltage) versus time is called electrocardiogram. An example of the ECG pulse graph is shown in Figure 2. In each ECG graph all the pulses, duration of these pulses and time interval can be predicted denoted by P, Q, R, S, T and U as depicting in Figure 2. The P wave is the atrial depolarization with time period of 80ms to 100ms; QRS complex is the depolarization of both right and left ventricles with time period of 80ms to 120ms (atria repolarization simultaneously), while T and U waves are ventricular repolarization.
The positions of the placement of ECG electrode is shown in figure 1, where LA (Left Arm), LL (Left Leg), RA (Right Arm) and RL (Right Leg) refer to the bipolar limb leads. In

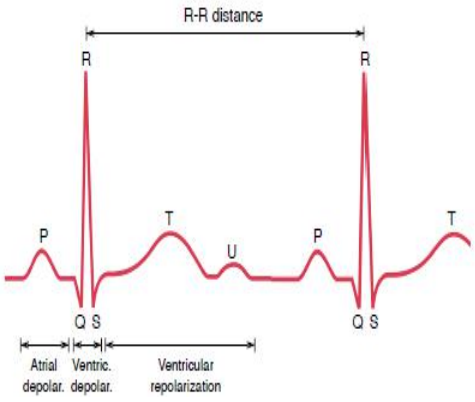

Figure. 2: Typical ECG Pulse [2]

ECG, the term lead refers to the signal of the voltage difference between two electrodes. Figure 3 is also shown the limb leads positions. For ECG in bipolar limb lead configuration, electrodes are normally placed on arms or legs as according to their place mentioned in their names but these electrodes can also be placed as shown in Figure 1. V1, V2, V3, V4, V5 and V6 are the unipolar leads used for Wilson's Central Terminal (WCT) voltage measurement.

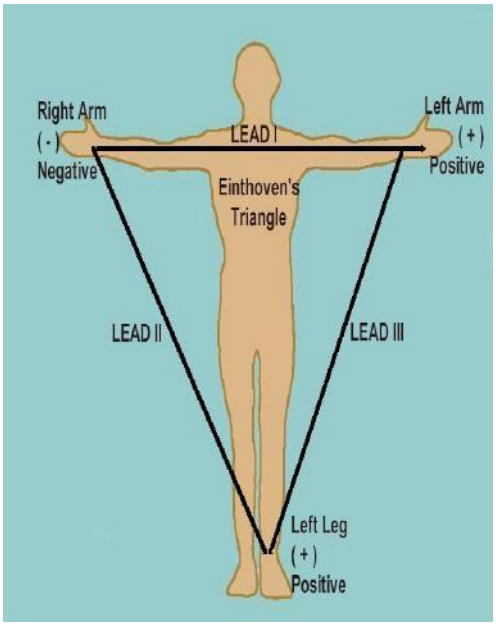

Figure. 3: [The Limb leads]

A diagnostic technique which is used for assessing the condition (health) of skeleton muscles and motor neurons is called Electromyography (EMG) [3] . Motor neurons are nerve cells which control the muscles through transmitting the electrical signal. These electrical signals are detected through tiny electrodes. Intramuscular EMG and skin surface EMG are the two types of EMG.

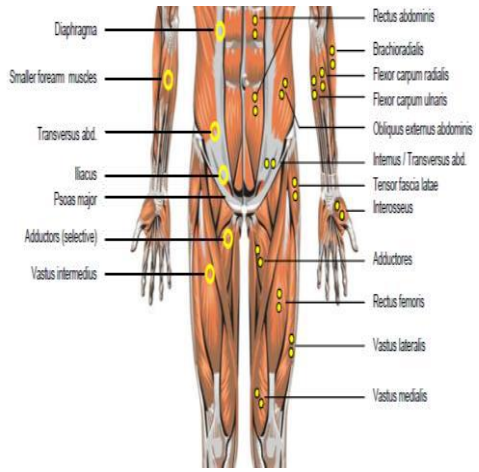

Figure. 4: Anatomical Positions of Selected Electrode Sites, Frontal View [3]

In intramuscular EMG, a needle or fine wire inserted into the muscle tissue for recording the electrical activity and is used for deep muscular analysis. In Skin surface EMG, surface electrodes are adhesively tapped to the skin to measure the electrical activity between two or more points of a surface muscle tissue. EMG can be used for identifying the muscle fatigue, nerve dysfunction and problem in signal transmission from nerves to muscles.
Furthermore in this paper, a study related to some available wireless biosensor platforms which are used in different healthcare applications, the technologies and the sensor types used in these platforms is presented. Also in this paper we investigate and discuss the ECG and surface EMG based work has been done so far using SHIMMER^{TM} sensor platform [4]. The reason behind the selection of SHIMMER^{TM} sensor platform is its user friendly hardware and software development architecture, which suited for our future and current works in healthcare.

Rest of the paper is organized as follows, next section is Background in which issues and challenges in designing of wireless sensors, various wireless biosensor platforms and different applications of wearable bio sensor are discussed. In section 3, a comparative analysis between traditional ECG, EMG and wearable wireless ECG, EMG sensors is presented and finally the conclusion and future work is discussed.

2. Background

There have been several sensor platforms proposed and some are discussed here but before the discussion about sensor platforms, one should know about the issues and challenges associated with the designing and developments of the sensor platforms.

2.1. Issues and Challenges

A brief description of some issues and challenges is discussed in the following.
1) Wear-ability: In health care system, the majority of the users are patients. So to design such sensor platforms, one has to keep in mind the comfort and continuous health monitoring of the patients, the wireless sensors must be small in size and lightweight also easily wearable.

2) Energy efficient: As discussed earlier that the sensors used in WBSN are wearable or implanted inside the patient's body, therefore it is either impossible or very difficult to change the energy source of the sensor keeping in mind the discomfort of the patient. Therefore the sensor should be operated in low power. It will increase the lifetime of the sensor.

3) Reliability: Using the wearable wireless bio-sensors in healthcare, reliability is another most important factor in designing of sensor node platform because the treatment of the patients heavily depends on the data acquired from these wearable wireless bio-sensors. Therefore the sensor node platform should be accurate in terms of capturing, filtering and preprocessing of the sensed data. Another aspect also should be considered while talking of reliability i.e. data

forwarding. A biosensor node should have the ability to forward the sensed data to coordinator.

4) Multi-Hop: In some critical scenarios when patients are not allowed to carry their PDA or mobile phones, then the wireless sensor attached to patients should be able to communicate in multi-hop manner. It means the sensor node not only sense and send its own data but also send the data of a node which is connected only to it or that node is selected for forwarding the data. In some cases the relay node is used for forwarding the sensor node's data.

5) Latency: As discussed earlier these wireless biosensors are used for remote monitoring. Therefore some sensors like ECG, EMG, and BP are most important in the process of treatment. The data acquired from these types of sensors is so critical and needs continuous monitoring. Therefore latency in data should not be tolerated. One has to keep in mind this while designing a sensor platform.

There are some other considerations regarding the designing of a wireless sensor node to develop a WBSN that one needs to keep in mind before designing such platforms. Some of these considerations are Quality of Services QoS, reliability and self-organization. A class based QoS Model [5] which prioritized the data according to sensor types, Reliable Proactive Routing Protocol [6] which ensures the reliability of data sending and receiving, and the study [7], in which authors present the provisioning of the introduction of self-organization in WBSN.

2.2. Wireless Bio-Sensor Platforms:

There are several wireless biosensors platforms proposed in past 10 to 15 years. Piotrowski et. al [8] proposed a microcontroller (MSP430F5438A) based ultra-low power wireless sensor node platform called IHPNode platform. In this proposed sensor node platform, authors used three different types of transceivers which are, European 868 MHz band (radio module CC1101), the 2.4 GHz band (radio module CC2500). The last one contained ZigBee 2.4 GHz (radio module CC2520). These sensor nodes have two 16 Mbit large flash module and a SD card slot with the support of 2 GB SD card. In this proposed platform authors considered the monitoring of firefighting scenario. Different types of bio-sensors, inertial sensors, and pressure and temperature sensors are placed on each fire fighter according to their work responsibility. The types of parameter chosen for prototyping are heart rate, blood oxygen saturation, temperature in the fire fighter jacket, air temperature, air humidity, methane concentration, carbon monoxide concentration, air cylinder pressure, orange smoke above, temperature above etc. authors claims the prototype is working fine and ready for use in such other applications.

Chen et al. [9] proposed a low-cost, tiny, lightweight (wearable), ultra-low-power (long lasting), flexible (for research purpose) sensor platform for Wireless Body Area Sensor Network (WBSN). In this architecture, authors used microcontroller (MSP430F1611) for processing and ChipCon CC2420 radio for communication. They developed an electrocardiography (ECG) prototype for initial assessment, and the signal acquired from ECG prototype is transmitted to a PC through a Telos mote, so real time ECG signal will be displayed on PC.

Yamaguchi et al. [10] proposed a low power field programming gate array (FPGA) based sensor node working on 950 MHz frequency. In this microcontroller (MSP430) and FPGA based architecture, authors introduce sensors like, temperature sensor, infrared sensor, sound sensor, light sensor and 3D acceleration based sensor. The main theme of using FPGA is co-processing of the

acquired data, sensor interface and aggregation of the data. There is no support for physiological sensors.

In [11], authors proposed architecture for ECG home health monitoring, in which they used a sensor node, a relay (hopping) node and a based station node. 3 lead ECG node is made-up with a bio-potential amplifier for single supply operation. The relay node is based on low power 8-bit microcontroller PIC18F452. XBee RF Wireless module which has the frequency of 2.4 GHz is used for radio transmission and reception.

In[12], authors proposed a sensor node platform, in which authors introduced two microcontroller based architecture for kinematic sensor with a µSD card for long-term storage of the data. The core microcontroller is Jennic JN5148 which supports IEEE802.15.4 radio transceiver. The other one is ATMega32 which supports USB connectivity. Authors claim that their proposed platform is highly customizable in terms of both the software and hardware and can be integrated with inertial sensors for better results but not supported to the physiological sensors.

Beside above mentioned platforms, some other professionally available platforms are also discussed here.

The BioRadio physiological monitor[13] is a wireless platform used for analysis of different physiological signals such as ECG, EMG, and EEG etc. It works on Bluetooth with range of 10 meter. The maximum data rate is up to 200 Kbps. It can continuous works up to 8 hours with memory of 4 GB. The manufacturer claims that it is the best solution for research, physiological signal monitoring and teaching. The major drawback of this platform is it only works on Microsoft Windows 7 or later operating systems (OS). Therefore it is not possible to use it other OS such as MAC or Linux distributions. BioRadio mote is shown in Figure 5.

Qardiocore[14] is another officially available wearable platform which is used for continuous ECG monitoring. It requires a device compatible with APPLE iOS 9.0 or later only. The most important feature of this device is it is free from wires or patches. It is easy to use with a chest strap as depicted in figure 6.

Figure. 5 BioRadio Technology[13]

Figure. 6 Qardiocore Technology[14]

BTS analysis system[15] is another system also professionally available platform which is used for analysis of EMG Signals. This system can be used in medical practice, sports and research. Its EMG device BTS FREEEMG is the smallest EMG device in the

world claimed by its manufacturer. BTSFREEEMG uses Wireless IEEE standard 802.15.4 for wireless data transmission. It can also continuously record the data up to 8 hours.

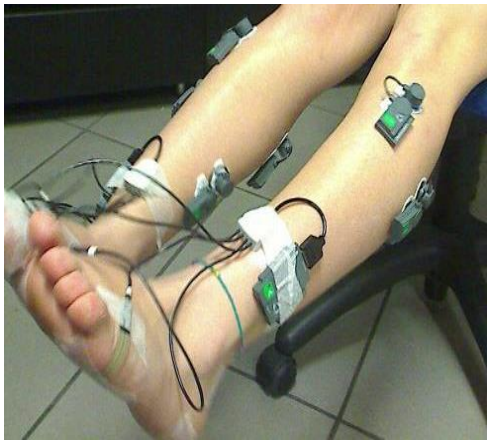

Figure. 7 BTS FREEEMG[15]

Sensing Health with Intelligence, Modularity, Mobility and Experimental Reusability (SHIMMER) [4] is a well reputed wearable sensor platform designed for research and commercial use and well suited for wearable applications. A system developed with Shimmer wearable sensors enables the real time processing, transmission and display of the sensed data with the simple and effective capturing from the body. Shimmer proposes a flexible wireless sensor platform with wide range of application, control over capturing the data, and scientifically reliable data for interpretation and reliable data. It uses MSP430 microcontroller for core computation and ChipCon CC2420 radio for communication. Besides this the micro SD card socket is also given in shimmer devices with the support of 2 GB. Shimmer has the variety of sensing capabilities like kinematic, physiological and ambient sensing through their daughter board add-ons. Shimmer also allows software development in different tools such as C#, MATLAB, Android and LabVIEW so it can be easily integrated with Shimmer.

Figure. 8: SHIMMER Mote [4]

2.3. Application Systems

In this subsection some ECG and EMG based applications are discussed.

In[16], Android Java-DSP [AJDSP] application was proposed for educational purpose of signal processing courses. The students not only can easily understand the different concepts of signal processing but also test and design their own DSP algorithms and by using different configurations on their android devices. AJDSP can generate Musical Instrument Digital Interface (MIDI) waveforms, Dual Tone Multiple Frequencies (DTMF) waveforms, deterministic and random signals. It can also produce not only the different frequency and time domain signal processing functions but also different algorithms such as Fast Fourier transforms (FFT), z-domain operations and filter design also implemented.

In[17], authors proposed a femtocell based approach to integrate two different types of sensor networks which are Body Sensors Network (BSN) and Ambient Sensors Network (ASN) to provide remote monitoring of a house of patients. In this study, four lead based Shimmer ECG sensors are used for BSN while IRIS mote with MTS400 Sensor Board is used ASN that includes various

ambient sensors such as humidity and temperature sensors, light sensor, barometric pressure sensors and 2D-accelerometer. The ECG experiment is done through placement of four ECG leads on left arm (LA), left leg (LL), right arm (RA) and right leg (RL) with the rate of sampling frequency set to 512 Hz. Authors used a peak detection algorithm to detect QRS complex and identify the R peaks correctly with threshold mechanism and finding local maxima in time series, they find out the heart rate of the patient using through identifying the correct R peak and sampling rate.

In[18] authors present a wearable Shimmer biosensors (ECG and surface EMG) with an Android smartphone based solution for continuous monitoring of patients in daily life. The activity they selected in this study is biking. In this study, standard limb lead II of Einthoven's triangle as shown in figure 3 is selected for ECG data. The electrodes for RA and LL are positioned as given in figure 1. A QRS detection algorithm is used which has different digital signal processing steps processed on raw data of 10 seconds. The first step is band pass filter (comprises of the cascading of low pass and high pass filter) for attenuation of noise, following by 5 steps differentiation, then squaring method and in last moving window integration. With this method author's claim 94.76% heart beat detection rate for 60 seconds (or 6 samples).

In this study EMG is used for treadle detection. The EMG electrodes are placed on the Vastus lateralis and the Vastus medialis muscles as shown in figure 3. Authors claims that the placement of EMG electrodes on these muscles produced satisfactory results. The raw data is processed firstly with squaring for computing the energy of the signals and then moving window process is used for treadle detection. In total of 60 seconds (6 samples with each of the samples comprises of 10 seconds), authors claim 91.25% detection rate for treadles.

There are some other works have been done so far using Shimmer physiological sensors. For example an ECG based real time allergy detection [19], an EMG based analytical study on BB (bicep brachii) muscles [20], a real time joint angle measurement using EMG [21], an ECG based patient monitoring system [22], athlete ECG monitoring system [23] and activity aware ECG based patient authentication for remote health monitoring [2]. Adnan et. Al [24] highlighted different area in which WBSN can help and also proposed new application areas for WBSN also presented a brief comparison of different sensor applications.

3. Comparative Analysis

In this section a comparison between traditional EMG and ECG with wearable wireless biosensor is presented. In some cases the wearable biosensor outperformed their counterparts as shown in table 1.

3.1. Advantages

There are some advantages of wearable wireless biosensors discussed here.

1) Flexibility: Compared with traditional ECG and EMG machines, the wireless biosensor are lightweight and easily wearable. A battery is used for power and in most sensors platforms it can be recharged, while traditional ECG, EMG machines require electrical sockets where these machines can be plugged-in.

2) Size: Normally a wearable wireless biosensor is small in size while traditional ECG and EMG are hand handled machines, require some space where they can be placed on especially designed tables or frames.

3) Mobility: The wireless biosensors are lightweight and tiny devices, therefore these can be worn by a patient or person and patient or person can move with ease, while traditional machines are hand-handled, and therefore these are quite difficult to move

from one place to another while connected with patients.

4) Availability: A person or patient can wear these biosensors at any time and any place without any difficulty, while traditional devices are fixed at one place while connected to patients.

5) Freedom of natural behavior: If a person wants to acquire ECG or EMG through traditional devices, which means he/she should perform some simulated activities. It means that person should be ready for unease environment where he/she cannot feel or express his/her feelings with freedom according to his/her own will. In contrast to this a person or patient can do routine work while connected with wearable bio sensors.

6) Any time data acquisition and monitoring: Wearable biosensors enable the acquisition of real time data at any time and any place. Therefore, it allows the real time monitoring of the patient. While traditional machines do not have these type of luxuries.

7) Real time solution: A bio sensor work by a patient can send the data to patient's smart device (smart phone) for continuous monitoring. With the help of smart computing devices where some anomaly detection algorithms, if any anomaly in pattern of acquired data is found then the device identifies it and suggest the patient to take some proactive measures through notification (text message or alarm). This facility can be used in remote monitoring where a message sent to care giver or doctor through smart phone to take some necessary actions.

A. Limitations

There are some limitation of using these bio-sensors.

1) Accuracy: Accuracy is one of the biggest factor, sometimes false alarm could be generated. Although some sensor platforms claim that their sensors are 99% accurate but there is always a chance, for example misplacing the electrodes or electrodes are not adhesively tapped with body.

2) Power source: Batteries are used in these wireless sensors for powering the sensors, which became discharged so either these batteries should be replaced or recharged. The patient may feel uncomfortable when the battery of the sensor is either changed or recharged. It is also to be remembered that the smart device has also a battery which also needs to be charged due to continue receiving (also some sending) the data from sensors and computation which are battery discharging processes.

Table1: Comparison of ECG and EMG (Traditional Vs. Wireless Sensors)

ECG & EMG Types	Flexibility	Size	Mobility Type	Availability	Freedom	Data Acquisition	Real time Solution	Accuracy	Power Source	Connectivity
Traditional Machines	No (in terms of fix)	Required some Space	Hand Handled	Only in particular places	Not much	In a particular time	Once done, doctor will respond	Very High	Electrical wall socket (unlimited)	Not required
Wireless Bio-sensors	Yes	Tiny, Small	Wearable	Anywhere	Yes	Anywhere	Yes (any time)	Low Compare to Traditional	Battery (Limited)	Required

3) Connectivity: It is also recommended that when using a wearable wireless bio Table sensors are used, the connectivity between smart phone and the sensors should be well-maintained otherwise the crucial data may be lost

4. Conclusion and Future Direction

In today's world, the importance of wireless sensors in an individual's life is increasing rapidly. Therefore, this field has emerged as one of the top most research area. In this study, two types of biosensors (ECG, EMG) are selected to discuss because of their applications in healthcare. In first, some basic knowledge of ECG and EMG is presented. Then some already proposed physiological wireless sensors platforms are presented. Besides this, a detailed discussion is presented about the issues and challenges facing in designing and developments of wireless sensors especially for healthcare applications. There are some applications based on SHIMMER™ sensor platform also discussed. In last, ECG and EMG sensors are compared with traditional ECG and EMG equipment in terms of different parameters. In future, SHIMMER™ IMU (Inertial Measurement Unit) and SHIMMER™ EMG will be used for fall detection and fall risk assessment in elderly.

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Fast Performance Computing Model for Smart Distributed Power Systems

Umair Younas, B. Khan, S. M. Ali
Department of Electrical Engineering COMSATS Institute of Information Technology
22060 Abbottabad, Pakistan
umair.ciitatd@gmail.com, bilalkhan@ciit.net.pk, hallianali@ciit.net.pk

Alfredo Vaccaro
Department of Engineering, University of Sannio
82100 Benevento, Italy
vaccaro@unisannio.it

Abstract

Plug-in Electric Vehicles (PEVs) are becoming the more prominent solution compared to fossil fuels cars technology due to its significant role in Greenhouse Gas (GHG) reduction, flexible storage, and ancillary service provision as a Distributed Generation (DG) resource in Vehicle to Grid (V2G) regulation mode. However, large-scale penetration of PEVs and growing demand of energy intensive Data Centers (DCs) brings undesirable higher load peaks in electricity demand hence, impose supply-demand imbalance and threaten the reliability of wholesale and retail power market. In order to overcome the aforementioned challenges, the proposed research considers smart Distributed Power System (DPS) comprising conventional sources, renewable energy, V2G regulation, and flexible storage energy resources. Moreover, price and incentive based Demand Response (DR) programs are implemented to sustain the balance between net demand and available generating resources in the DPS. In addition, we adapted a novel strategy to implement the computational intensive jobs of the proposed DPS model including incoming load profiles, V2G regulation, battery State of Charge (SOC) indication, and fast computation in decision based automated DR algorithm using Fast Performance Computing resources of DCs. In response, DPS provide economical and stable power to DCs under strict power quality constraints. Finally, the improved results are verified using case study of ISO California integrated with hybrid generation.

Keywords: Smart Distributed Power System, Plug-in Electric Vehicles (PEVs), Demand Response (DR), Data Centers, Renewable Energy

1. Introduction

Transport sector is one of the major contributor in rising energy demand, environmental pollution, GHG emissions, and fuel consumption as presented Figure 1. Likewise, growing trend towards internet traffic, e-commerce, big data, increasing digital contents enlarged the workload and ultimately maximize the power consumption of DCs [1]. Besides the Residential, Commercial, and Industrial (RCI) load,

combine PEVs fleet charging, and massive energy consumption of DCs brings higher load peaks in overall electricity demand.

This massive power demand increases the stress on power system hence, disturb the balance and reliability of power system. First, we proceed with the detailed description regarding impact and role of PEVs in power system. PEVs are recently the emerging paradigm that provide undeniable socio-economic benefits, Greenhouse Gas (GHG) reduction, and replace gasoline fuels dependency with electricity, without violating the consumer preferences [2]. Besides, PEVs have the potential to offer reliable performance, safety, versatility, energy storage, and bidirectional power flow operation within smart grid.

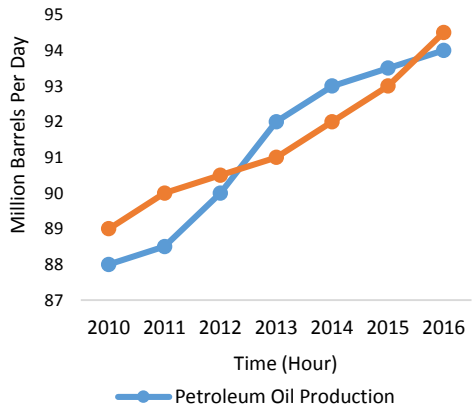

Figure 1: Global Growth in Petroleum Fuel

Despite the facilitating nature, large scale pervasion of PEVs increase peak load demand that further provoke considerable load impact on DPS if not properly managed and controlled [4]. However, optimal power consumption in charging of PEV's fleet become a challenge for modern researchers. Therefore, the authors in [5] presented gamming algorithm and real time load management approach [6] to optimize power consumption in PEV's charging. Likewise, optimization algorithms concerned with peak load demands of bulky EVs are presented in [7], and [8]. While, virtual power player based simulation technique is applied to accomplish DSM and V2G operations [9]. While, the authors in [10] incorporated DR scheduling policy for energy management of PEVs.

Secondly, another big challenge is the massive energy consumption of DCs including; Google, Microsoft, Amazon, Apple, and Facebook DCs. Just a single renowned Google DCs utilize more than 260 MW power, which can satisfy the power demand of 100,000 to 200,000 people. Likewise, Microsoft DC in Quincy, Washington utilize 48 MW electricity that is enough to fulfil the power demand of 40,000 homes [11]. In 2013, the power consumption of DCs in U.S. was approximated 91 billion Kilowatt-hours. While, the future consumption is expected to reach 140 billion Kilo-Watt hours in 2020 and annually 100 million metric tons of carbon is created due to DC power utilization [12].

The literature review suggests that power system researchers are independently implementing various control schemes and optimization algorithms to minimize the distributed power consumption [13], [14].

Correspondingly, DC operators are individually using optimization strategies to minimize the operational cost and maximize the overall revenue. In the proposed work, we present a novel solution to utilize the online computing services of DC to solve the complex and computational intensive functions of DPS in smart grid like; a) fast computational response in DR services, b) fast information and communications flow between user and ISO, c) online large flexible volatile storage availability, and d) fast performance of optimization algorithm for selecting the appropriate available resource to meet the desired load demand. To the best of our knowledge, this holistic vision has not been explored in the power system domain. The main contributions of our work are:

- Initially, we modelled fixed and controllable loads, and mix-generation resources connected to utility grid/ISO,
- The decision theory based multi-objective constrained optimization algorithm based on proposed model is implemented on ISO California, which constitutes about 71,823 MW generation capacity and have 28,000 MW peak load demand for a typical day in May 2016,
- We consider both PEVs and DCs load as prosumers, these are not only act as electric load but also provide ancillary services to the proposed DPS model,
- Grid supply and demand balance is sustained by using time and incentive based DR strategies (scheduling, shifting, and curtailment of load),
- Data center computational services are encouraged to accomplish fast computations to sustain the reliability of overall power system hence, fast and reliable services encourage customers to participate in DR programs.

The rest of the paper is organized as follows: Section II describe the multi-objective model of the proposed system design. In this section, we implemented decision based theory algorithm. Later, performance evaluation and the impact of ancillary services of data center on power system reliability and also revenue model of data center is analyzed in section III. Section IV concludes the paper with a brief summary and proposal enhancement of the current work.

2. System Model Design

In order to accommodate large-scale deployment of distributed RES and EVs penetration, unlike traditional deterministic optimization approaches, we are dealing with load/generation multi-criteria patterns hence, static scalar optimization is not optimal solution. However, to overcome the limitations, we formalize a constrained multi objective optimization problem that can be solved by any following non-linear programming techniques e.g. goal-attainment method, normal boundary injection, strength Pareto evolutionary algorithm, modified fuzzy based evolutionary algorithm. As, the abovementioned algorithms work perfectly when input parameters are determined.

However, in our work input conditions are uncertain hence, upgraded modified algorithms are required to incorporate data uncertainties in real time systems. The system architecture is demonstrated in Figure 2.

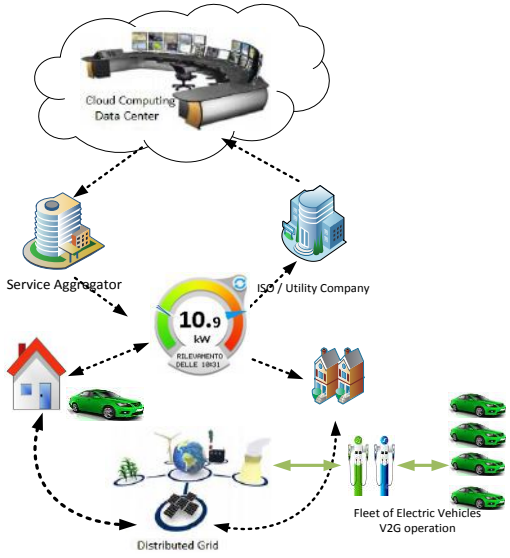

Figure. 2: System Architecture of the Proposed Model Design

In the proposed methodology, the desired objective is to maximize the revenue for both the utility/ISO and its customers. Customer's revenue is maximized by encouraging their participation in DR programs in order to reduce the power consumption and electric bills as presented in (1);

$$Revenue = \sum_{t=1}^{T} P_F(t) \sum_{i}^{N} L_i(t) + C_{sel} \sum_{t=1}^{T} \left(\sum_{i=1}^{N} L_i(t) - \overline{X} \right)^2 \quad (1)$$

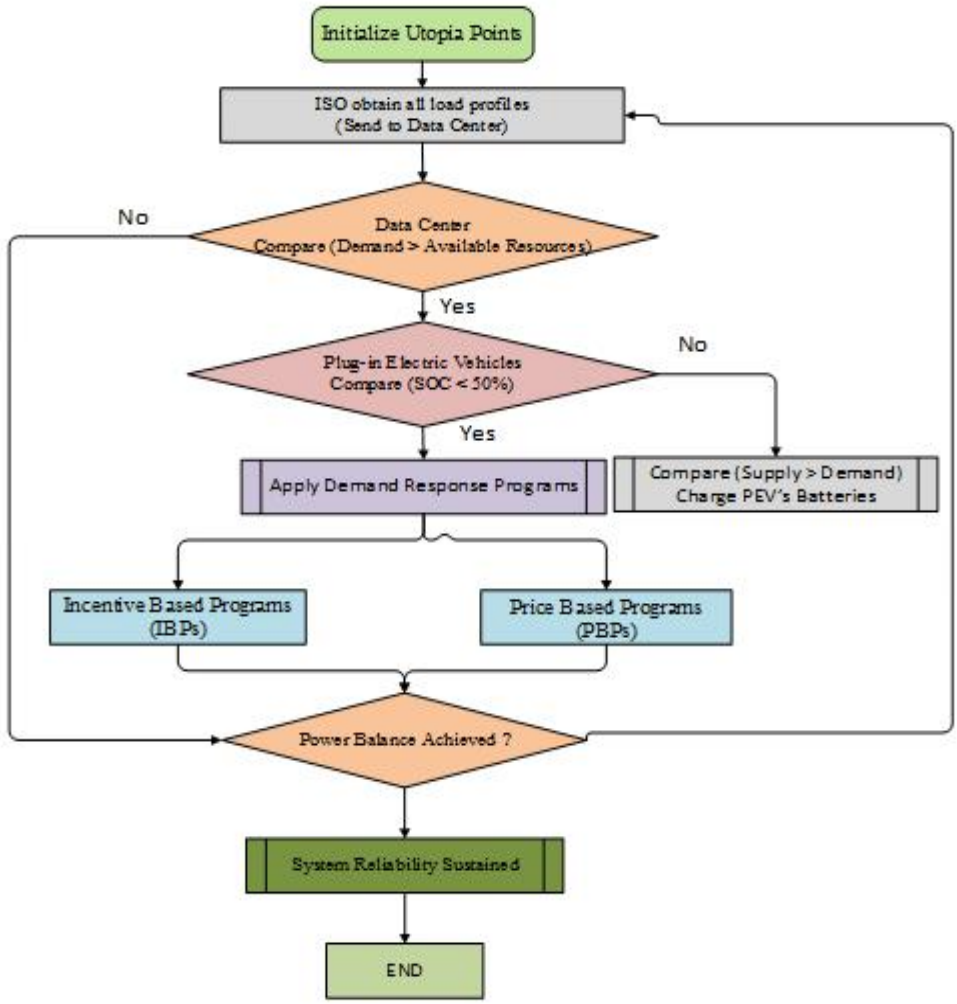

Figure. 3: Flow of Information between ISO and End-Customers

$$L_i(t) = L_i^F(t) + L_i^C(t) + L_i^{EV}(t) + L_i^D(t), \quad \forall\, t \text{ and } i \qquad (2)$$

$$\overline{X} = (1/T) \sum_{t=1}^{T} \sum_{i=1}^{N} L_i(t) \qquad (3)$$

Where

$P_F(t)$ total power consumption by fixed load at time t;

$L_i(t)$ sum of all fixed and controllable loads at time t;

$\overline{X}$ average daily power consumption of user i at time t

$L_i^F(t)$ total Fixed load of user i at time t

$L_i^C(t)$ total controllable load of user i at time t

$L_i^{EV}(t)$ total electric vehicle load of user i at time t

C_{sel} C-select ranges [0:1] and describe dynamic of uncertain load

As, the above problem is comprised of two objective functions hence, the model can be re-written as; $Revenue = F1 + F2$ where,

$$F1 = \sum_{t=1}^{T} P_F(t) \sum_{i}^{N} L_i(t) \ ,$$

$$F2 = C_{sel} \sum_{t=1}^{T} \left(\sum_{i=1}^{N} L_i(t) - \overline{X} \right)^2,$$

The generalized representation of the proposed optimization problem is modelled in (4)

$$\begin{cases} \min\limits_{x} \quad \alpha_{F_1} \frac{F_1(x)}{\overline{F_1}} + \alpha_{F_2} \frac{F_2(x)}{\overline{F_2}} \\ s.t. \quad Battery_{SOC(0)} = Battery_{SOC(T)}, \\ P_{GRID(t)} + P_{DRES(t)} \geq P_{L_i(t)} \\ P_{L_i^C(t)} = 0 \quad \forall\ t \in [T_{ON}, T_{OFF}] \\ P_{GRID(t)^{min}} < P_{GRID(t)} < P_{GRID(t)^{max}} \\ \sum_{i=1}^{N} LB_i < \sum_{i=1}^{N} x_i < \sum_{i=1}^{N} UB_i \end{cases} \quad (4)$$

$P_{L_i^C(t)}$ power consumption of controllable load of user i at time t

T_{ON} Start time of the DR event duration

T_{OFF} Stop time for the DR event duration

$SOC(0)$ initial state of the charge of the storage battery $SOC(T)$ final state of the charge of the storage battery

The proposed optimization model in (4) perform the revenue maximization in the presence of defined constraints. The optimized outputs contain DR time vector, dynamic load profiles, and available generation profiles to sustain DPS's reliability and balance between the demand and supply. The customers are able to schedule their electric load by participating time based and price based DR programs. In this way, customers maximize their revenue by reducing electric consumptions and bills. Likewise, when users minimize their consumption then high peaks will be flattened by valley filling and reliability of proposed DPS further improve. The flowchart of overall system is presented in Figure 3.

3. Performance Evaluation

3.1. Case Study

Worldwide, US is leading in sales of PEVs and particularly largest number of sales and registration of EVs are observed in California State as presented in Figure 4 [15]. Therefore, we consider the case study of ISO California (CAISO) and collected it data for simulation purpose to analyze the impact of PEVs penetration on real power market. Total mixed installed generation capacity of ISO California energy sources is observed 71,823 MW while, the average peak load demand of May 2016 is 28,000 MW. The total 50,000 EVs are considered with annual mileage of 14,600 miles per day for each EV. In this work, the major contributions are based on large scale integration of RES and PEV's fleet. However, the ISO California is rich in RES and capable of dealing large number of EVs as demonstrated in Figure 5 hence, the state perfectly matches the proposed objective.

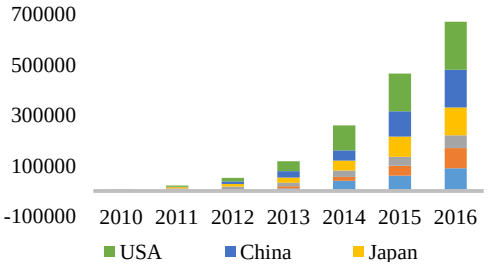

Figure. 4: Worldwide Sales of EVs from 2010 – 2016 [15]

In California, more than 50% of PEVs sales are analyzed. As, large scale integration of PEVs desire large storage bank hence, PEV fleet can provide large storage to intermittent RES.Meanwhile, combine charging of fleet of PEVs also impose adverse effect on grid

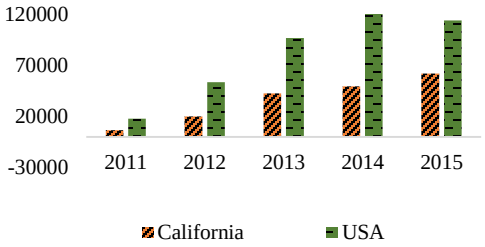

Figure 5: Contribution of California State in Total US Sales of PEVs [15]

overload, which is further elaborated in this paper.

3.2. Supply and Demand of ISO California

The total generation capacity and average load demand of ISO California is presented in Figure 6. While, net renewable generation capacity is illustrated in Figure 7. In this case, the grid is not overloaded because of large scale renewable potential of California. While, the state is perfectly suit to analyze the impact of PEVs charging on power system.

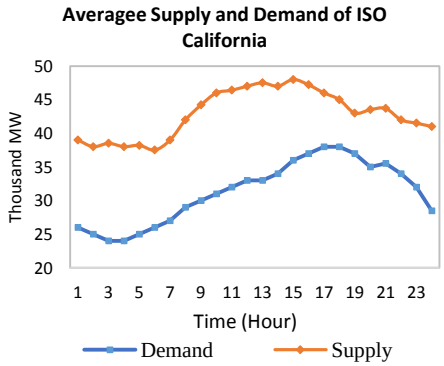

Figure. 6: Installed generation and average load demand of ISO California

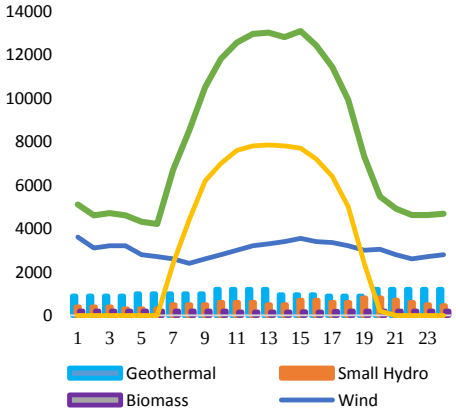

Figure. 7: Average RES Generation of ISO California in Typical Day May 2016

3.3. Behavior of Uncontrolled EV charging on Load Profiles

In this research, we introduced three charging scenarios of 50,000 EVs. However, the impact of each scenario is evaluated. In first scenario, the owners are interested to charge their EVs just after coming back to home from evening to late night. However, the combine charging of EVs at same time increase average residential load and brings undesirable higher peaks in overall load demand as shown in Figure 8. Furthermore, without any proper control the peak demand in residential load is almost doubled, which necessitate the increase in base load generation, increased power losses, and disturbed the sustainability and reliability of power system.

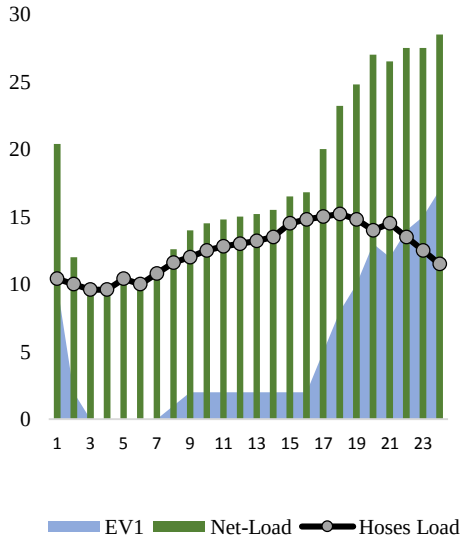

Figure. 8: Impact of Uncontrolled EVs on load demand in Scenario 01

While in the second scenario, the EV's owners are interested to charge their EVs in midnight hours when the prices are low. The impact of the charging of all EVs in these hours increase the load peaks for shorts hours Figure 9. In DR programs section, we overwhelmed these large peaks in load demand.

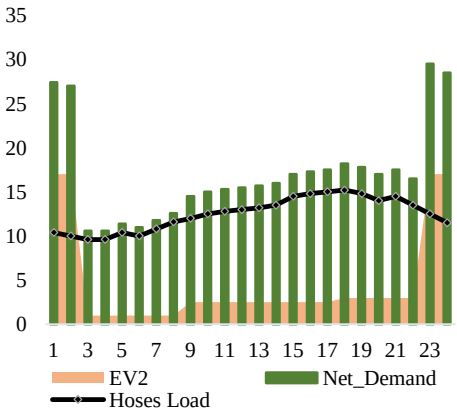

Figure. 9: Impact of Uncontrolled EVs on load demand in Scenario 2

PEV's owners are interested to charge their EVs in early morning hours. The combined charging effect is analyzed in Figure 10 while, next section proceeded with DR implementation to minimize this effect.

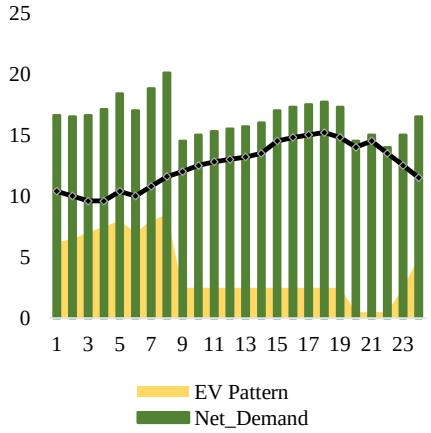

Figure. 10: Impact of Uncontrolled EVs on load demand in Scenario 3

3.4. EV Charging Controlled using DR Programs

DR is referred to the changes adopted by the customers in order to minimize the power consumption, when power system is jeopardized. PEVs are considered as the cheap promising DR resource to enhance power system reliability by minimizing the load fluctuations [16]. DR programs are basically divided into two main groups namely; a) Incentive based Programs (IBPs), and b) Price Based Programs (PBPs). PBPs are further categorized into Time of Use (TOU), Real Time Pricing (RTP), and Critical Peak Pricing (CPP). In PBPs, usually the electricity prices are more during higher peak demand and less during low peaks [17]. While, IBPs are offered to customers who show willingness to participate in DR programs through credit bill or discount rate. In this work, we incorporated PBPs to select the pricing policies for the incoming load profiles and IBPs are employed in order to get benefit from ancillary services of PEVs in V2G operating mode in higher peak hours. RTP DR strategy in scenario 01 verify load reduction and minimize spinning reserves and base load generation as presented in Figure 11.

In Figure 12, TOU pricing scheme is presented (Not to scale) while, comparative results with Figure 9 declare the huge reduction in peak load demand from 28 (unit MW) to 20 (unit MW). However, this is a big achievement and it allow the flexibility to accommodate more EVs.

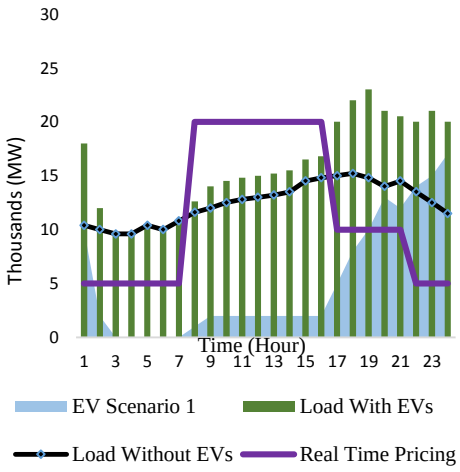

Figure. 11: Load Reduction Using RTP DR Scheme in Scenario 1

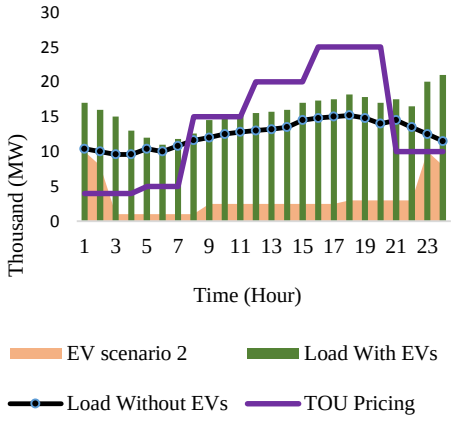

Figure. 12: Load distribution using TOU pricing scheme in Scenario 2

Likewise, CPP DR event is called when the residential demand exceeded 20 thousand MW as illustrated in Figure 13. During CPP event, the prices are high so customers schedule or shift their load in peak hours and power system balance maintained due to load curtailment.

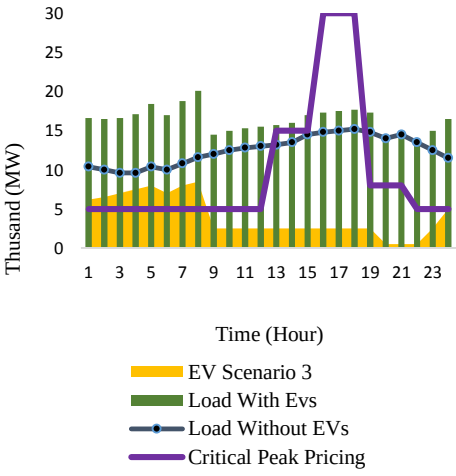

Figure. 13: Implementation of CPP DR Strategy in Scenario 3

3.5. Ancillary Services of Green Data Centers

In this work, the power hungry data centers are not only considered as an electrical load but also as an opportunity, because smart grid need fast computational infrastructure to visualize, monitor, manage, and control its applications. The holistic approach of this paper declares that the incorporation of fast parallel cloud computing services of data center enhance introduce the concept of virtualization in power system by providing; a) volatile flexible economical energy storage capacity, b) decrease the computational time of the tasks of proposed DPS, c) improve reliability of the system in term of service evaluations, and d) power system do not need to install large computational infrastructure, hence cost and revenue optimization is achieved in the proposed work, the ancillary services of cloud data center are highlighted in Figure 14. In this paper, we implemented decision based theory optimization algorithm to accomplish enhanced reliability of power system by using DR programs.

The simulation model is then evaluated through Amazon EC2 cloud in order to ensure the computational intelligence of the proposed model. In the presence of fast computing services of the data center the convergence and scheduling time of the DPS jobs/tasks is reduced and improved

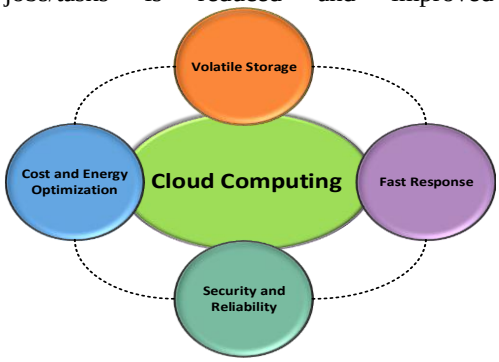

Figure.14: Cloud computing features for Power System

reliability. In the light of data center services, the average residential load without DR and with DR are depicted in Figure 15. However, it is cleared from the results and discussion that EVs are cheap controllable sources for DR. In this case study almost 10 (thousand MW) reduction (scheduling, shifting, and curtailment) is ensured using DR schemes. Moreover, this paper successfully achieved

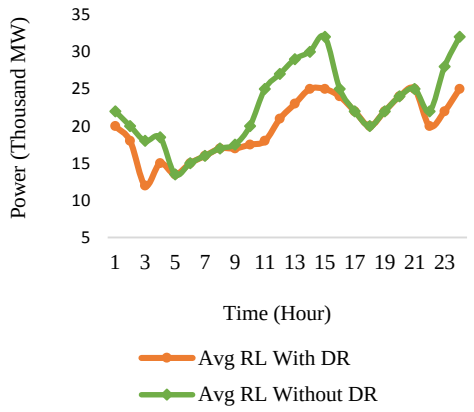

Figure 15: Average Residential Load Reduction Using DR Programs

the 50,000 EVs penetration for ISO California and declared that PEVs are the optimal solution to increase storage capacity for surplus power and plays important role in V2G regulation in peak times.

3.6. Impact of Ancillary Services of Data Center on DPS

The importance and key contributions of the fast computational resources of the data center are already explained. Furthermore, the outcomes of data center's incorporation in proposed DPS are presented below:

- Computational Time: Computational time in power system prospective is the most important factor, particularly in job scheduling, resource allocation, and OPF convergence to satisfy the balance between supply and demand in power system and also avoid the system from threats and outages.
- Batch Job/task: In addition to large typical workload, data center is responsible to execute the power system jobs on first priority basis.
- In order to sustain optimal power consumption, data center divide the proposed DPS jobs in three categories: (a) Longest Job First (LJF), (b) Shortest Job First (SJF), and (c) Shortest Remaining Time First (SRTF) and the comparison of all scheduling techniques are presented in Figure 16.

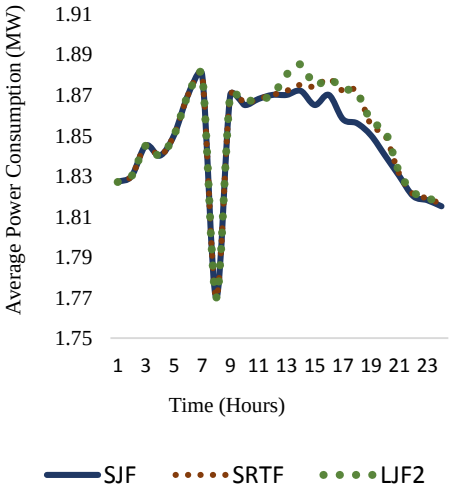

Figure 16: Cloud Computing DR Scheduling Techniques Implemented on DPS

In proposed DPS, it is noticed that in the morning hours and the time of low peak demand, the behavior of all schemes is similar while, the major difference is observed in the time of peak load demand.

4. Conclusion

This paper proposed the decision based optimization model for the proposed model comprising uncertain distributed RES integration, large scale PEV deployment and

V2G regulation mode of PEVs. Moreover, three different behaviors of PEV's charging patterns are considered for simulation. In order to optimize power consumption, optimal scheduling strategy selection is performed by decision based algorithm. Later, the selected DR strategy is implemented on abovementioned three scenarios of charging patterns. For each scenario, individual results are calculated with significant load reduction, shifting, and shaping is envisioned. Moreover, cloud computing data centers offered fast computations services on prioritized basis to perform the power system jobs like DR programs, V2G regulation etc. In response, power system provides stable and economic power to data center which is the basic need of data center.

In future, the objective is to enhance this work by including Optimal Power Flow calculation using Newton Raphson method in the light of data center ancillary services. Furthermore, the simulations results will be performed in term of timespan, job preemptions, and makespan.

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Pervasive Electricity Distribution System

Muhammad Usman Tahir, Mohammad Asif Khan, Ahmad Waqas, Shahneel Siddiqui
Department of Electrical Engineering, Sukkur Institute of Business Administration Sukkur, Pakistan
usman.ee@iba-suk.edu.pk , asif.khan@iba-suk.edu.pk , shahneel.ee@iba-suk.edu.pk , ahmad.waqas@iba-suk.edu.pk

Abstract

Now a days a country cannot become economically strong until and unless it has enough electrical power to fulfil industrial and domestic needs. Electrical power being the pillar of any country's economy, needs to be used in an efficient way. The same step is taken here by proposing a new system for energy distribution from substation to consumer houses, also it monitors the consumer consumption and record data. Unlike traditional manual Electrical systems, pervasive electricity distribution system (PEDS) introduces a fresh perspective to monitor the feeder line status at distribution and consumer level. In this system an effort is taken to address the issues of electricity theft, manual billing, online monitoring of electrical distribution system and automatic control of electrical distribution points. The project is designed using microcontroller and different sensors, its GUI is designed in Labview software.

Keywords: component; Pervasive, Smart Grid, Power Distribution

1. Introduction

Currently Pakistan is suffering from severe energy crisis. Energy is part and parcel of every aspect of life as well as backbone of a country's economy. Pakistan is lagging behind in this area despite rich reserves of raw energy, still the country is struggling to fulfil its energy needs. There is a dire need for the investment and proper use of these reserves for driving the wheel of economy. Steps must be taken to eliminate the electricity theft around the country and minimize the usage of electricity to save our future generations from facing further energy crisis [1].

In this project a system has been developed to reduce the energy consumption around the country and eliminate the theft of electricity which is happening in different areas of Pakistan. The project is based on specifically three parts: substation, distribution and the consumer device unit. Substation works as the main control center which has total authority to allow and disallow any connection to any consumer, and also has the ability to detect any theft. The substation also monitors the usage of electricity provided to consumers and the feeder lines. The Distribution works as the current sensor calculates the flow of Power through the Electrical cables that are used to distribute power to the consumer houses, from the sensor system sends the data to the substation via Cellular Network. The Consumer device works as the Smart Energy Meter. There is also a touch screen panel for consumers that

provides various functions to the consumer which include monitoring of the energy consumed by the load and controlling the usage of electricity by setting a limit of Energy Units to be consumed by the load.

Implementation of this project will reduce the over usage of electricity by the consumers, and will provide an interface to the users through which they can monitor their usage of electricity. The system will also detect electricity theft, if occurred, and will alert the substation instantaneously. The system aims to eliminate the settlement between the Meter Readers and the consumers, as the system will end the role of meter readers to manually read the Energy Units consumed by each customer. Successful implementation of this system around the country will reduce the energy consumption by a good rate, in turn decreasing the rate of electricity load-shedding in Pakistan making the lives of people happier and better.

The paper is divided into five sections. Section II is about the existing electrical infrastructure which is present in Pakistan for the distribution of electrical power to homes and industry. Section III is about the PEDS, its architecture, different parts of the project and working principle. Section IV is about the different results taken during experimentations of the project. Section V will tell you about the different work carried out to solve the said problem.

2. Existing Manual Electricity Distribution System

The energy infrastructure of Pakistan is not up to date and well-maintained, rather it is considered to be underdeveloped and poorly managed. Currently the country is facing severe energy crisis. Despite strong economic growth and rising energy demand during the past decade, no serious efforts have been made to install new power generation plants. On the other hand demand for electrical power is increasing day by day.

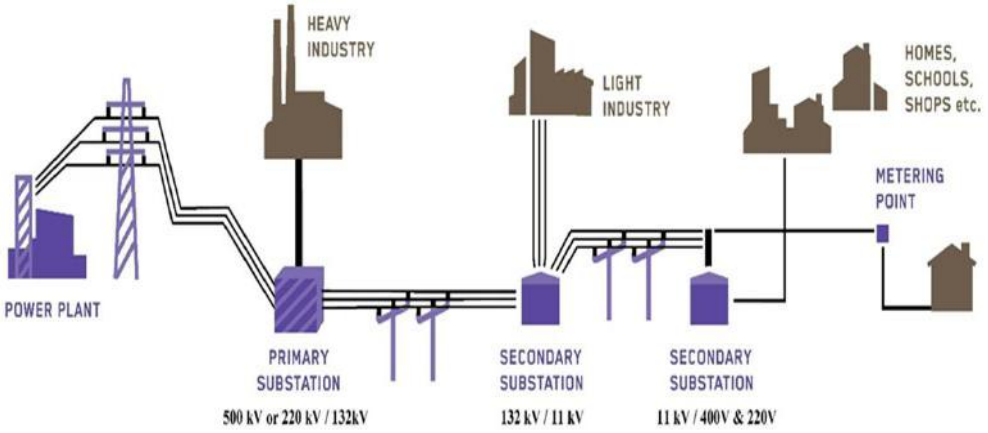

Figure. 1: Exiting Electrical Distribution System

The rapid demand growth, transmission losses due to outdated infrastructure, power theft, and seasonal reductions in the availability of hydropower have worsened the situation. Consequently, the demand exceeds supply and hence load-shedding is a common phenomenon through power shutdown. In the existing system the power is being distributed to primary substation which is being step up by the station to 500kv or 220/132 kv and transmitted

on transmission lines of long distances. The 500kv is then being received at secondary substation which steps it down to 11kv for transmitting it to shorter distances to the distribution transformers where it is stepped down to 400v and 220v for domestic usage. Currently there is no system in Pakistan to monitor the transmission of power from secondary substation to transformer point and from transformer to consumers. Most of the connection and maintenance is done manually. The connectivity of the existing electrical transmission and distribution system is show in Fig.1.

To improve the existing system various incentive rate design have been implemented in the past to improve the power transmission process and to minimize the line losses [2]. Power transformation from power plant to substation is reasonable but from substation to consumer level it is going worst. This happens due to poor monitoring system, manual metering devices, human interaction and electricity theft. In traditional electricity distribution systems, metering is done only at one point consumer level. There is no care about in and out measurement of power at distribution transformer as shown in Fig.1. The main limitations of the existing system are electricity theft, manual operations, fault rectification, manual billing and highly human dependent system.

3. Pervasive Electricity Distribution System

Pervasive electricity distribution system (PEDS) aims to decrease the theft, corruptions, and extra usage of electricity by the consumers and would bring transparency in the distribution, hence decreasing the shortfall of electricity around the globe and Pakistan. The system is designed to replace the old power distribution system.

3.1. Main Features of the System

The main purpose of this system is to design a smart electricity distribution system which can eliminate electricity theft and reduce the energy consumption and provide an interface to the customer which in turn would help him to monitor and control the usage of electricity. This system would also serve:

- To eliminate the need of manual meter readers to read the units of energy consumption
- To smartly calculate the energy units of all houses
- To alert the distribution unit, if any electricity theft is occurred
- To implement a real time communication between substation and distribution units through a GSM network
- To provide a smart interface to the user, which can help him to monitor and control the electricity usage via a touch screen module

3.2. System Architecture

The system is mainly consisting of three major parts: the substation unit, distribution unit and consumer device unit. The substation unit mainly consists of a computer on which GUI will be provided for controlling distribution and collection of data. The system will be able to communicate wirelessly via cellular network. The substation unit maintains a database of every user which contains the information about the energy usage of every customer from time to time and produces a monthly record of units consumed in the form of a bill. The substation unit is managed by the electricity providers.

The substation has a control over all of its customers, and has the authority to allow or terminate the connection of any customer at any time, and it also houses an indicator to detect any occurring electricity theft in the area. The substation unit also produces graph of power being consumed of each customer

and calculates the power at the distribution and matches it with the power readings that it gets via cellular network from consumer devices. If no match occurs, the theft seems to have occurred.

The distribution unit is installed at distribution transformer from where electricity connection is provided to every user. This unit has microcontroller, current and voltage sensors, relay and cellular GSM shield for wireless communication. It senses the power that flows through the lines to the users and calculates the total power that flows before it is being distributed to the consumer, and keeps sending the data to the substation for monitoring and maintenance purpose [3].

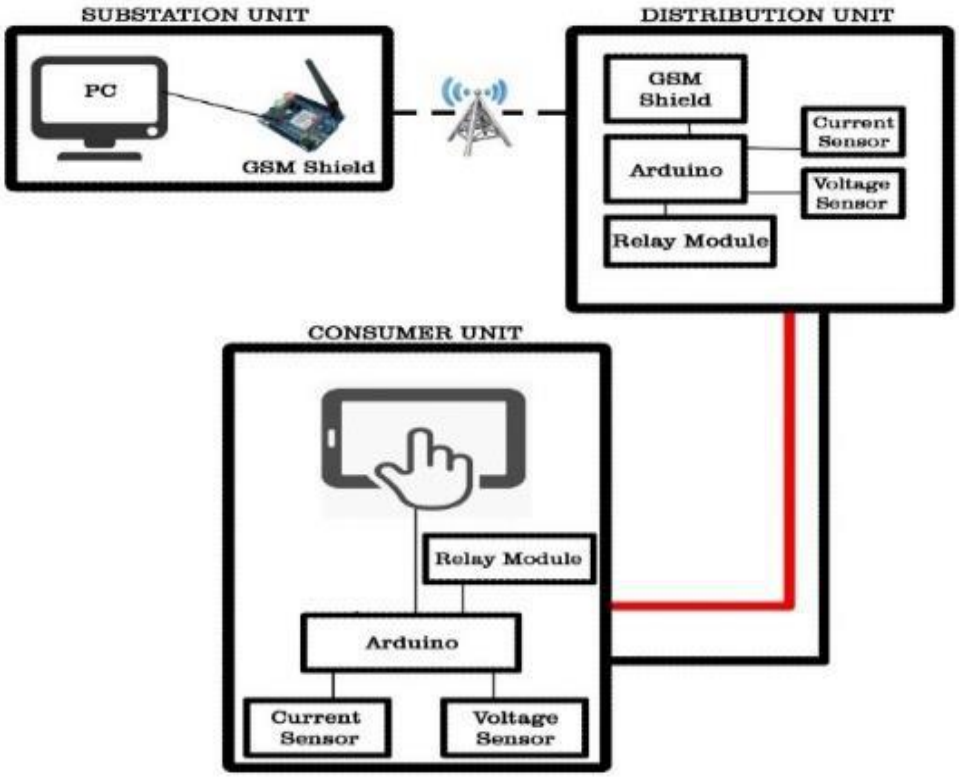

Figure. 2: PEDS System Architecture

The consumer device unit performs various functions. It is basically a touch screen LCD that is interfaced via Arduino and allows the user to control the usage of load and monitor the energy usage of the load. The consumer device of the project holds an option for the consumer to monitor its energy usage, where the consumer would be able to view the energy readings including the voltage reading, current reading, and the multiplication of both, that is, power reading. The user can also view a graph power vs. time of the load. The consumer device of the project serves the customer to control his usage of electricity by setting a limit of energy usage of the house. Once the energy limit is set to a particular value, then the load will be disconnected from

the supply of electricity as soon as the power consumed has reached up to the value of the energy limit. The complete system model is depicted in Fig. 2.

3.3. GUI development in LabView

In PEDS, there is a strong role of control interface at substation. This system is designed in LabView with user friendly GUI. The main program or server program contains multiple Windows. Home window is the first window on server for selection of a particular feeder. By selecting a particular feeder, another window appears for selection of a particular user in that feeder. In this window, there is a list of many users in that feeder. When we select a particular user, we can see user description, history of bills and a textbox to send text to a particular user.

This is the main window which appears at PC on which LabView is installed in substation unit [4]. This window provides a selection menu for feeder lines which are Feeder Lines, Users, Energy Ratings, History, Termination Option and Theft Detection, as shown in Fig. 3. Each option is having its own window and multiple functions for the remote monitoring and controlling of the data which is gathered from remote devices installed at distribution unit and consumer devices.

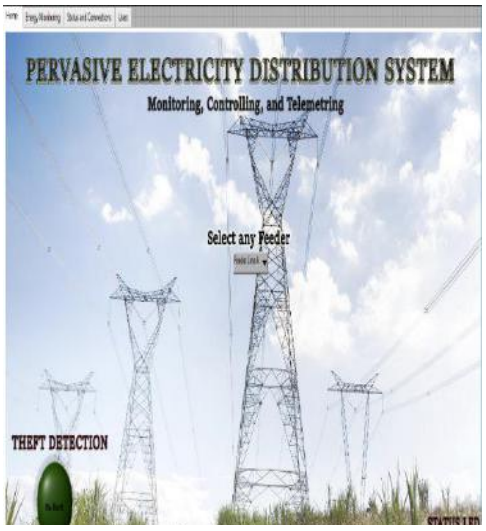

Figure. 3: Substation GUI window

3.4. Consumer Device Unit of the Project

The consumer device unit of this project is to be fitted inside the houses of the consumers. It incorporates a touch screen panel that provides a graphical user interface to the consumers to use various functions shown in Fig. 4, like to see energy consumption, set energy consumption limit, display consumption graph and display credits.

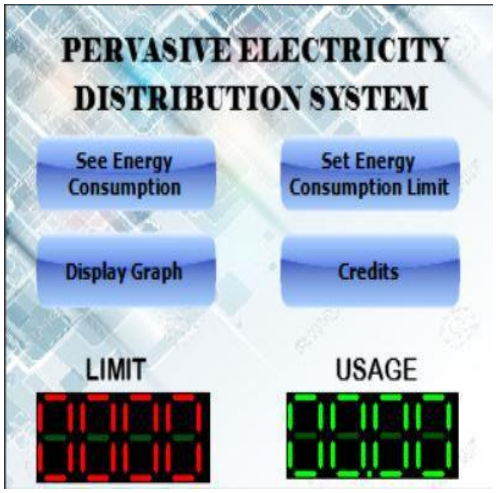

Figure. 4: Consumer Device GUI

4. Results

The prototype of the PEDS was developed and results were gathered to test the novelty of the system. Real-time test of the system was done by connecting an electrical load to it. The main purpose was to feed data to the system in the real-time manner, also to detect electricity theft and remote control from substation GUI. Table 1 shows reading regarding theft detection. Current sensor 1 measures the current of load one, current sensor 2 measures the current of load two and current main line is the current measured at transformer via substation unit. The sum of

currents of individual users is compared with total current, unbalanced results depict theft detection. In the last row of the table shows imbalance in current. The sum of currents of individual user is 4 amperes, whereas total current at transformer is 5 amperes, it means 1 amperes of current is theft and also same is the case in the third row.

Table 1: Theft Detection

S. No.	Current at User A	Current at User B	Current at Distribution	Theft Detection LED
01	1 A	1 A	2 A	OFF
02	2 A	1 A	3 A	OFF
03	1 A	2 A	4 A	ON
04	2 A	2 A	4 A	OFF
05	2 A	2 A	5 A	ON

Electricity theft can be detected easily in any feeder line at substation by the software`s home window so that company can take action. The software designed in LabView maintains the Database of every use in excel file as shown in the figure of User B displaying the power consumption of each user at every instant of time as it is illustrated in the Fig. 5 and Fig. 6.

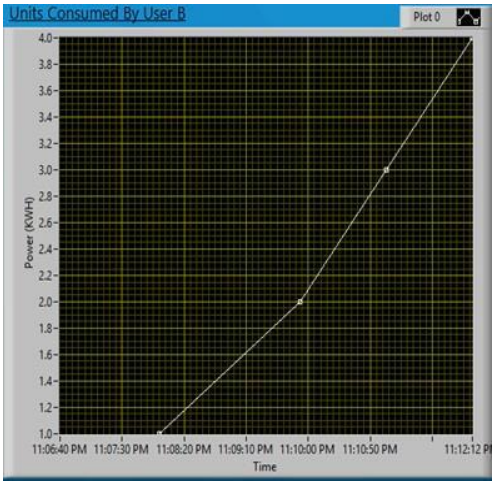

Figure. 5: User "A" Real-time Consumption

The system is capable of maintaining the real-time consumption of every user which is connected to the distribution transformer. The graph is plotted between the kWh and the current time.

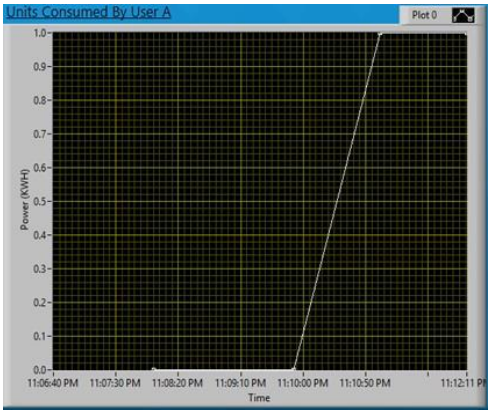

Figure. 6: User "B" Real-Time Consumption

5. Related Work

The importance of electrical power has forced the research world to do some good work to make electrical systems more reliable, efficient and affordable. In this regard, different researchers have worked on smart grid technologies. The background of the research includes Energy Management System, Demand Side Management, Load Management, Smart Grid, Pole Mounted Transformer Protection, Telemetry and Remote Monitoring and Management (RMM) [5]. Xuenan Gu et al. (2016) have worked on method for load transfer in case of any fault, their main target is to secure the important customer by providing power in case of fault [6]. Devidas, A.R et al. (2010) have worked on the development of smart system for controlling power transmission faults, power theft by using sensors nodes at various power points to monitor the power and act accordingly [7]. Habib Elkhorchani et .al. (2010) are working on the communication

modeling between the different parts of a smart grid system [8]. Neal Master et al. (2014) have worked on the decentralized modeling of smart by using different algorithms [9].

6. Conclusion and Future Work

In this project of Pervasive Electricity Distribution System the work has been done to overcome major issues with current existing outdated energy transmission infrastructure of the country. Currently the main issues of the current energy crises are the electricity theft done by consumers, wrong meter reading and waste of human resources over meter reading, losses during transmission, manual electrical grid working. Also the usage of electricity at homes is not efficient or optimized. This project has been developed by keeping in view the above issues. With this project theft can be reduced by automatic meter reading system, also substations can be automated to have remote control of consumers' connection and their status.

The future expansion of this project will be divided into two parts: one for consumers and other for distribution and substation units. Machine learning can be used to find the patterns of user usage and to automate switching accordingly. The second part of the project needs fine tuning for testing it in real electrical distribution and substation units.

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Spatial Data Analysis: Recommendations for Educational Infrastructure in Sindh

Abdul Aziz Ansari, M. Abdul Rehman, Ahmad Waqas, Shafaq Siddiqui
Department of Computer Science, Sukkur IBA, Pakistan
aziz.mscs2013@iba-suk.edu.pk , rehman@iba-suk.edu.pk , ahmad.waqas@iba-suk.edu.pk, shafaq.siraj@iba-suk.edu.pk

Abstract

Analysing the Education infrastructure has become a crucial activity in imparting quality teaching and resources to students. Facilitations required in improving current education status and future schools is an important analytical component. This is best achieved through a Geographical Information System (GIS) analysis of the spatial distribution of schools. In this work, we will execute GIS Analytics on the rural and urban school distributions in Sindh, Pakistan. Using a reliable dataset collected from an international survey team, GIS analysis is done with respect to: 1) school locations, 2) school facilities (water, sanitation, class rooms etc.) and 3) student's results. We will carry out analysis at district level by presenting several spatial results. Correlational analysis of highly influential factors, which may impact the educational performance will generate recommendations for planning and development in weak areas which will provide useful insights regarding effective utilization of resources and new locations to build future schools. The time series analysis will predict the future results which may be witnessed through keen observations and data collections.

Keywords: Spatial analytics, Data Analytics, Education, GIS.

1. Introduction

Education is highly significant element for a developing country like Pakistan. Keeping this fact in perspective, Government of Pakistan has allocated sufficient amount of budget for improving education to Grass-root level. Standardized Achievement Test (SAT) is a reform initiative, a very timely and needful strategy to explore the dynamics of student learning in Sindh province. 'World Bank' also recognizes the effectiveness of SAT. Project SAT focuses on attitudinal changes in teachers and students effective learning influenced by the environment and infrastructure provided on regional basis. This study presents the analysis of data collected from SAT project. According to several reports including SAT-I, II and III, the quality of education throughout the Sindh province is alarming. According to SAT-II report, a test was conducted of the students of class V and VIII in three subjects, i.e. Science, Language and Math. SAT-II results show that the overall average score in all subjects is below 30% in all regions of Sindh province, which definitely a crucial situation. There may be several reasons of such failure, like teachers, physical infrastructure, language problems or the locations of schools.

ASER National Report 2015 indicates a critical education status in Sindh

rural areas. The report indicates that less than 40% students capable of reading, writing stories in Sindhi, Urdu or English and doing basic mathematical operations [1]. ASER 2014 Sindh rural report shows alarming situations in various aspects of its education. Table 1.1 shows statistics gathered from ASER 2014 Sindh Rural Report [2]

Table 1: Learning Levels

LEARNING LEVELS (CLASS 5)			
English	24% can read sentences in English		
Urdu/Sindhi	41% can read story in Urdu/Sindh		
Arithmetic	31% can do 2-Digit division in arithmetic		
FACILITIES AVAILABLE FOR GOVERNMENT PRIMARY SCHOOLS			
Funds: 26%	Useable Water: 59%	Boundary Wall: 64%	Useable Toilets:48%

Reform Support Unit (RSU) also shows the statistics about the condition of education in sindh. Table 2 shows statistics of SAT 2014-15[3].

Table 2: Content Strand Based Scores ClassV

Subject	**Content Strand**	**Content Strand Average (%)**	**Subject & Overall Average (%)**	**Standard Deviation**
Language	***Reading***	54.16	32.81	18.6
	Writing	11.47		
Math	***Number & Operation***	18.70	18.22	12.78
	Measurement	37.74		
	Geometry	14.65		
	Information Handling	11.56		
Science	***Life Science***	14.76	15.26	11.04
	Physical Science	14.49		
	Earth & Space Science	28.46		
Overall Scores (%)			22.10	11.79

1.1. Geographical Information System

Geographical Information System (GIS) helps us visualize, analyse, interpret and understand data to reveal relationships and trends. According to Foorte, K.E and M.Lynch:"A geographic information system (or GIS) is a system designed to capture, store, manipulate, manage, and present spatial or geographical data" [4].In the beginning, use of GIS was aimed at the creation of maps only. The automation of paper based maps provided new idea of analysing data geographically using geometrical shapes and the database/linked data. This method was initiated by the Harvard Lab for Computer Graphics [5].

1.2. Quantum gis

QGIS (Quantum GIS) is stable open source geographic desktop application that provides efficient data viewing and analysis capabilities. Different countries and organization prefer GIS based analysis of available data that helps them in designing robust policies for the future of the country. Various independent international works have been carried out in order to infer the hidden factors that determine the progress of the education system in their particular country or region.

1.3. Geostatistics

Statistics is the science of producing facts and figures based on real/sample data by applying some analytical methods like finding

averages, correlations, regression etc. This is an inferential approach to make decisions. The merger of GIS and Statistics came with new dimensions of analytics. In spatial/geo statistical analysis objects are represented by basic geographical symbols like lines, points and polygons. GIS presents spatial information to have independent analysis based on various features that highlight hidden patterns within data [5].

1.4. Time Series Analysis and forecasting:

Time series is a set of observed points x noted at an identified time t [6]. Plotted points express the growing or declining behaviour of data. The ordered series should be continuous in nature. Most of the time, A traditional time series is composed of two major components: Seasonal variation and Trends. Seasonal component includes analysis of growth or pattern in periods i.e. weekly, monthly, quarterly or yearly, while Trend component is based on linear increasing or decreasing trend [7]. Selection of method is based on the context and nature of data. Time Series Forecasting is a method used to predict the future data. Observed time series points x1,x2,…,xN can lead to the next possible trend xN+h where h (h for forecasting horizon) is the lead time. Most of the literature has divided forecasting in three general classes which may be used together in some situations.

- Judgmental forecasts based on subjective judgment or perception.
- Univariate methods based on heuristic data series having some linear trends.
- Multivariate methods based on some predictors [7]

According to the literature review [7] seasonality is considered as additive if it is not dependent of local mean and sum of the tables over years' values generally are stabilized to$\sum i_t = 0$. Seasonality is considered as multiplicative if size of the seasonal variation is related to the local mean and sum of the year's values can be normalized by modifying the averagei_t=1. Regression, Moving average and Exponential Smoothing are some of the popular forecasting methods.

1.5. Pearson Correlation Coefficient

According to National Council on Measurement in Education (NCME), correlation coefficient r is a numeric value that determines the statistical relationship or dependencies between two variable/attributes [8]. This can define the positive, negative or neutral effect of an attribute on other within the same cluster. A positive relation indicates that the increasing change in attribute A, affects the attribute B positively or increasingly. Negative relation indicates a negative or decreasing effect on attribute B when attribute A changes increasingly. No relation indicates that attribute A has no effect on attribute B. It measures dependencies of variables by value -1 <r< +1. Correlation coefficient r can be formulated as:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\sqrt{n(\sum y^2) - (\sum y)^2}}$$

Where n is the number of data pairs and x and y are variables. Measures for correlation are as under:

- Correlation is said to be strong, if r≥±0.8
- Correlation is said to be weak, if r≤±0.4
- Correlation is said to be strong positive, if r is near to +1. If r=+1, then it is said to be a perfect positive correlation.
- Correlation is said to be strong negative, if r is near to -1. If r=-1, then it is said to be a perfect negative correlation.
- Correlation is said to be no-relation, if r is near to or is 0.

1.6. Univariate Forecasting Methods

As our data is not seasonal or multivariate, we must consider available methods to decide which would be appropriate to use. Available methods for univariate forecasting include Seasonal Moving Average (SMA), General/Simple Exponential Smoothing (SES) and Autoregressive Integrated Moving Average (ARIMA).

1.7. Seasonal Moving Average:

Moving average is a method to make time series data smooth by taking averages. Average is taken with or without weight values. This method can be applied to forecast data with seasonality. Forecast is predicted by observing average of last't' terms/seasons. Average moves with respect to time. Moving averages are calculated as F=t1+t2+…+tn. Seasonality may occur in data for several reasons like climate conditions Moving average is a method to make time series data smooth by taking averages. Average is taken with or without weight values. This method can be applied to forecast data with seasonality. Forecast is predicted by observing average of last 't' terms/seasons. Average moves with respect to time. Moving averages are calculated as F= (t1+t2+…+tn)/n to regulate the seasonality in time series. Seasonality defines episodic change in data which may occur for several reasons like climatic conditions, occasions, breaks etc. It spreads in different time periods like weekly, monthly, and quarterly or as factors discussed above. Seasonal variations can be expressed as a pattern or behaviour which leads towards future predictions.

1.8. General exponential smoothing

Exponential smoothing (also known as Simple or Single Exponential Smoothing) [9] is one of the empirical univariate forecasting methods [10]. Forecasting typically is based on smoothing averages of prior results. In a time series data, averages are supposed to be weighed by subsequent decaying patterns in averages. Unlike other univariate forecasting methods such as Moving Average (MA), Seasonal Moving Average (SMA) and Autoregressive Integrated Moving Average (ARIMA), General Exponential smoothing method is normally used to forecast such data where seasonality or trend is not present. Future value S_n+1is predicted by calculating weight average of the most recent results=aX_i+ (1-a) S_ (n-1). a is the constraint of level of the series which is considered as constant at local element of series and gradually changes over time [11]. The value of alpha can be selected by selecting the least Root Mean Squared Error (RMSE) where MSE = VARIANCE (errors) + (AVERAGE (errors)) ^2. Staring value (S0) is required in this method. Several methods have been proposed to calculate or to select the starting value. According to Gardner [11] although there is no significant empirical method of taking first value for forecast, but taking mean of data is the popular method while some consider first data segment in series as first value for forecasting. Gardner states exponential smoothing better as he found that accuracy of this method is amazingly accurate and easy to implement [11].

1.9. Autoregressive integrated moving average (ARIMA)

ARIMA is simplification of traditional Auto Regressive Moving Average (ARMA) model. It is used to predict future values from time series data. It is used mostly in the case where non-stationary process is observed which means there is a proof of change in mean and variance with respect to time. The integration of this model reduces the non-stationary process or non-seasonality. Box and Jenkins states three phases of ARIMA modelling: identification of time series properties of data, estimation of parameters of model and checking results of model with respect to hypothesis [10].

Rest of the paper is divided into 3 sections. Section 2 discusses the methodology. Section

3 demonstrates results and recommendations. Finally section 4 articulates conclusion and scope of future work.

2. Methodology

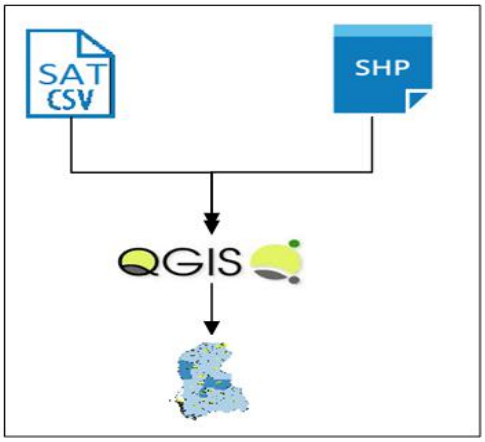


Figure 1: Architecture Diagram

Spatial Research framework shown in figure 1 shows the way this research work has been carried out. Following sections will briefly discuss each of the components in brief.

2.1. DATA PREPARATION:

Data preparation was a vital step of research. A chance of missing or unidentified record was present which was dealt. For preventing abnormal behaviours in analysis, data cleaning. Detected errors, altered outliers and filled missing data were performed. After removing the identified anomalies from the dataset, dataset was converted in a shape file. From shape file we extracted features which were appropriate to mapped against the spatial attributes of shape file.

2.2. Shape File:

Shape file is a simple, non-topological format for storing the geometric location and attribute information of geographic features [12]. We picked the map of Sindh in shape file with appropriate attributes to map data accordingly.

2.3. Data Mapping:

Collected data is in CSV (Comma Separated Value) format has been mapped with the features of shape file (.shp). The key spatial attributes for analysis were district attribute from the collected data set while it was the district spatial information attribute in the shape file. Figure 3.2 and 3.3 shows subject wise results of class 5 and 8 throughout Sindh province.

2.4. Feature Based Analysis:

Focus of this work is on finding influencing factors for education growth by analysing the results and facilities that are being provided in different schools across Sindh, Pakistan. So different attributes have been selected which are important parameters for highlighting the current status of facilities.

2.5. Data Visualization

For data visualization, we used SPSS and QGIS. Generated Scatter plots and histograms to visualize overall results as well as subject based results of class 5 and 8 students in Languages (Sindh/Urdu/English), Math and Science. Visual data stated the factual perspective of the problem.

2.6. Time Series Forecasting

Data compiled from last four year's (2013-2016) SAT results. Calculated overall averages for 23 districts of Sindh province, after compiling averages, identification of nature of time series data was the next step. Overall results were placed with years which concluded data as univariate by nature. Overall scores of 23 districts were mapped on four years, formulated as S_ij where S=Overall Scores, i=1, 2, 23 (districts) and j=1, 2, 3, 4(years). This formulation of data seems like panel data. As data is univariate and has no seasonality and no stable trend, we chose general exponential smoothing method for forecasting formulated asS_n=aX_i+ (1-a) S_(n-1). Alpha is the weight chosen by calculating the Root Mean Square Error

(RMSE) within values [13]. An optimal alpha value was selected from a number of calculation Alpha=Root (Mean Square Error), wherea≤0≤1. The table 3.3 shows RMSE for different values.

Table 1.3: Rmse at Different Alpha Value

Alpha	RMSE
0.1	2.61
0.2	2.69
0.3	2.75
0.4	2.80
0.5	2.85
0.6	2.91
0.7	2.99
0.8	3.09
0.9	3.21

RMSE 2.61 at Alpha 0.1 is the optimal weight in our case for smoothing forecasting [13]. After data preparation, the next step was to select first value for forecasting as it is the necessity of exponential smoothing method. Criteria for selecting first value were discussed earlier. We selected average of four years (2013, 2014, 2015, and 2016) data as first value for forecasting. Found predicted scores for 2017 to 2021 by using simple exponential forecasting method S_n=aX_i+(1-a) S_(n-1).

3. Results and Recommendations

Findings of analysis against geographical maps are discussed in this section. These findings lead us to propose some recommendations for authorities with some significant facts and figures. Most of the findings are based on factors derived from collected data.

3.1. Performance Influencing Factors:

This section includes discussion about some factors which may cause better performance and some assumptions which study has rejected. These factors were identified by significant statistical analysis on a number of attributes like scores, gender, medium, infrastructure, distance/location of schools, Teacher's information, student's family background, surveys, etc. All attributes were converted into numeric form for correlation analysis. Hypothetically by considering these factors, we can improve student's performance. Scores in three subjects Language, Math and Science generally influence overall performance and there is no need to find correlation. Table 4 shows correlation of different attributes with overall scores.

Table 4: Correlation of Attributes with Overall Average Scores

Factor	Correlation Coefficient
Working Male Teachers	-0.041**
Working Female Teachers	0.697**
Boundary Wall	0.590**
Toilet	0.102**
Drinking Water	0.508*
Electricity	0.51**
Computer Labs	0.571
Qualification Academic	0.401
Experience	0.518
Punctuality	0.555**
One task at a time	0.410*
Lesson plan	0.541*
Infrastructure	0.690
*. Correlation is significant at the 0.05 level (2-tailed).	
**. Correlation is significant at the 0.01 level (2-tailed)	

Results in table are clearly show positive, negative or no relation of attributes with overall performance. This rejects a common perception that spending more budgets only on building physical infrastructure leads towards better results. On behalf of our study we can say that including infrastructure, there are some important factors also, which may influence student performance. Cross-attribute analysis is another perspective of analysing correlation, through which we find positive correlation of Math subject with Science subject, which may conclude that by

emphasizing student's cognitive level in math may increase results in science also. Table 5 and figure 4.1 states cross-subject correlations.

TABLE 5 CROSS-SUBJECT CORRELATIONS

Subject	Correlation coefficient		
	Language	***Math***	***Science***
Language	-	0.452	0.498
Math	0.452	-	0.586
Science	0.498	0.586	-

Study found that increasing the number of female teachers for lower classes, providing proper infrastructure with basic facilities (such as drinking water, electricity boundary wall and computer labs), appointing experienced teachers and implementation of lesson plans may cause increase in overall performance. After observing a number of school's data, it is found that most of the schools don't have sufficient facilities and required infrastructure. Infrastructure plays a vital role in school performance, as it is a significant influencing factor. These facilities include Electricity, Toilet, Drinking water and some other factors. Electricity is the key facility for students, administration and teaching staff in order to run all learning processes smoothly within a school. Figure 2 depicts the electricity facility available in all districts of Sindh, Pakistan. The District with green is the one in which majority of schools do not have electricity facility available. On other hand the districts with blue Color are those, schools which are availing electricity facility.

Figure. 2: Electricity Facility

Drinking Water is the most important facility for human being to be availed. The statistics in figure 3 shows that majority of schools in Ghotki, Dadu, Nawabshah even do not have facilities of drinking water. Absence of such basic need may result in the shortage of attendance which may lead to even catastrophic results. This facility must be provided in each school so that it may not harm the education system in these districts.

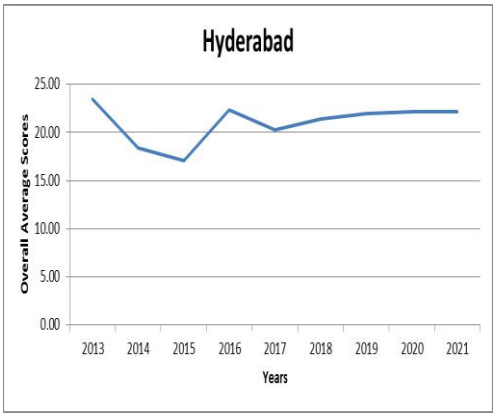
Figure. . 3: Drinking Water Facility

3.2. Time series forecasting

Table 5: Class 5 Overall Predicted Scores

District	2013	2014	2015	2016	2017	2018	2019	2020	2021
Badin	18.83	23.31	25.39	27.73	23.94	23.73	23.79	23.81	23.81
Dadu	17.88	20.88	23.86	26.08	22.30	22.09	22.15	22.17	22.17
Hyderabad	23.51	18.35	17.08	22.38	20.31	21.43	21.97	22.13	22.17
Jamshoro	22.48	21.30	23.37	27.94	23.86	22.77	22.34	22.21	22.18
Matiari	19.05	17.87	24.20	26.92	22.15	22.01	22.13	22.16	22.17
Shaheed Benazirabad	20.80	24.30	24.42	27.52	24.35	22.96	22.39	22.22	22.18
Tando Allah Yar	20.59	23.16	22.17	26.40	23.16	22.49	22.26	22.20	22.18
Tando Muhammad Khan	17.18	23.98	24.93	25.30	22.96	22.37	22.22	22.19	22.18
Thatta	15.67	19.14	22.06	25.66	20.78	21.44	21.96	22.13	22.17
Karachi City	32.00	27.00	23.74	30.50	30.70	31.71	31.95	31.99	32.00
Jacobabad	13.86	18.86	21.47	28.48	20.88	21.41	21.95	22.13	22.17
Qambar Shahdadkot	14.54	18.43	19.57	24.39	19.37	20.87	21.81	22.09	22.16
Kashmore	14.81	18.98	22.02	24.09	20.11	21.18	21.89	22.11	22.16
Larkana	15.41	17.11	17.92	22.35	18.30	20.48	21.70	22.07	22.15
Shikarpur	15.52	15.49	17.17	23.81	18.12	20.38	21.67	22.06	22.15
Mirpur Khas	19.81	25.68	26.32	25.68	24.45	23.02	22.41	22.23	22.19
Sanghar	18.03	24.00	19.88	26.26	22.13	22.05	22.14	22.17	22.17
Tharparkar	19.05	26.79	24.17	29.33	24.96	23.18	22.45	22.24	22.19
Umerkot	22.19	27.91	25.62	28.47	26.12	23.71	22.60	22.27	22.19
Ghotki	14.27	17.93	22.36	25.47	20.18	21.17	21.89	22.11	22.16
Khairpur	21.94	19.49	23.03	23.24	21.96	22.05	22.14	22.17	22.17
Naushahro Feroze	17.05	18.52	20.06	29.14	21.37	21.65	22.02	22.14	22.17
Sukkur	19.01	16.86	17.67	22.64	19.10	20.85	21.81	22.09	22.16

In this section, predicted scores and maps are discussed. Forecasting based on statistical analysis shows an approximate view of coming 6 years at district level which displays an insight into each district as well as whole province for the future. Results from 2013 to 2021(where scores from years 2013 to 2016 are real and from 2017 to 2021 are predicted) were compiled in SPSS and MS Excel. By using General Exponential Forecasting method we predicted scores for next five years. These predicted results were then mapped through QGIS. Table 6 shows predicted overall scores of Class 5.



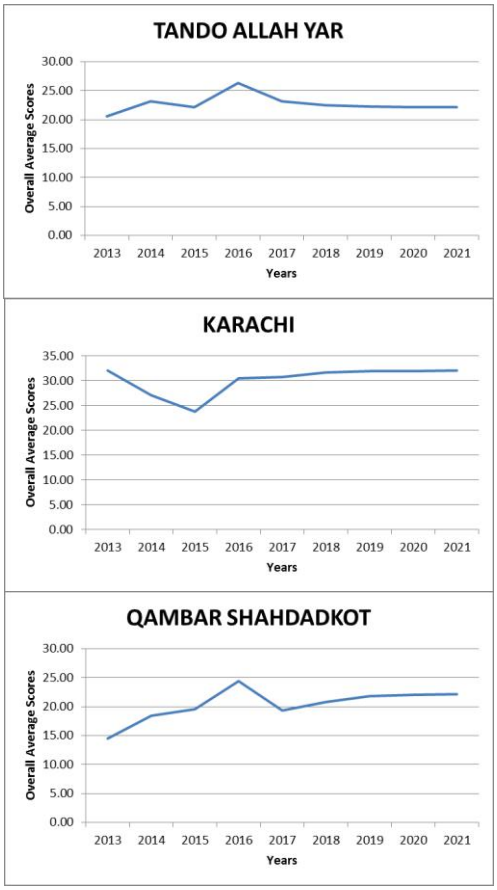
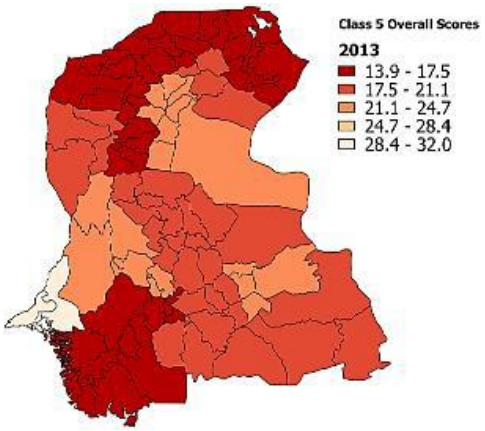
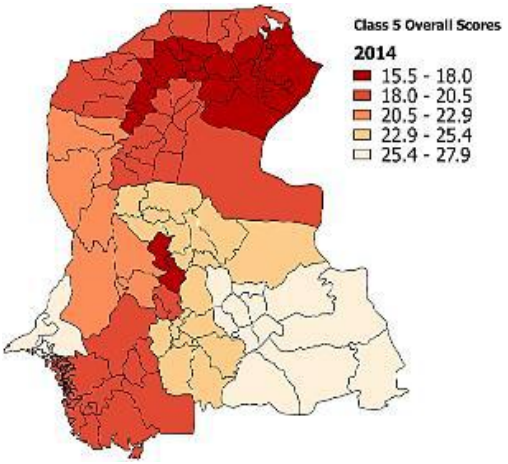


Figure. 4: Class 5 Overall Predicted Scores

Results shown above indicate crucial conditions for next 5 years, which may develop an assumption that the situation is getting worse. Class 5's results are showing a slowly increasing performance in some districts such as Karachi, Hyderabad, Qambar Shahdadkot, Larkana, Kashmore, Shikarpur, Ghotki and Sukkur. Above mentioned performance, As a matter of fact, it is still an alarming condition which must be considered as emergency, and needs to be tackled with immediate actions, whereas class 8's results indicate even worse condition. In class 8, most of the districts are showing a declining performance pattern, only a few districts like Karachi, Mirpur Khas and Sukkur display slow increasing performances, which still is a critical situation. Karachi is the only district which lies in the range of 25%-35% score, which if we consider as cross-match analysis among districts, is good, but still this is not overall a good result. Influencing factors should be considered for better performance. This study recommends that focus should also be on key cognitive development of subjects like Math and Science along with the provision of basic infrastructure throughout the province, which may produce better results. Figure 4.2.3and 4.2.4showing class 5 and 8 performance spatially with respect to time.





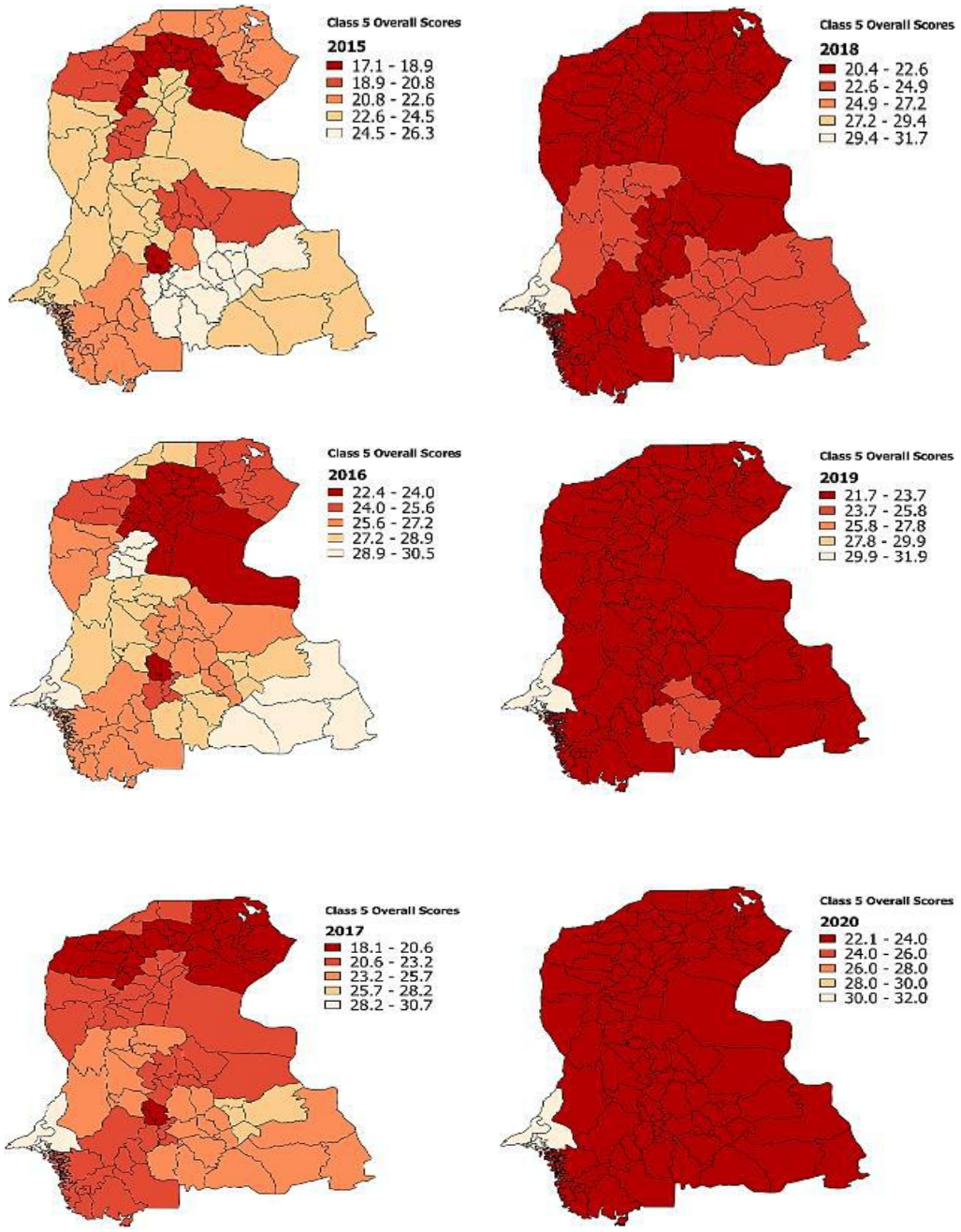


Figure.. 5: Class 5 Scores Map

4. Conclusion and Recommendations

Education is the most essential factor for development of a country. This factor is visualized graphically through geographical information system in all districts of Sindh, Pakistan. It has been observed in this research that even basic facilities like water, electricity and toilets are not available in various schools of Sindh, Pakistan. The task is to identify stimulating correlational factors that may cause raise in educational performance by analysing the datasets of schools, teachers and student's results, and predicting future image of situation in Sindh province. The analysis was carried out with respect to geographical locations at district level. There are some recommendations proposed by this study with the statistical support which should be considered to produce better results in future. Development and upgrading of infrastructure with basic facilities, appointment of well experienced faculty equipped with latest technology and techniques should be considered. Table 7 displays key influencing factors found in this study.

Table 7: Key Influencing Factors

Attribute	Correlation Coefficient
Working Female Teachers	0.697
Boundary Wall	0.590
Drinking Water	0.508
Electricity	0.510
Computer Labs	0.571
Experience	0.518
Lesson Plan	0.541
Infrastructure	0.690
Punctuality	0.555

Karachi, Hyderabad, Qambar Shahdadkot, Larkana, Kashmore, Shikarpur, Ghotki and Sukkur may produce better results in future. Future predictions are still alarming for critical situation of education performance at primary and secondary level.

5. Future work

Granularity is one of the key issues in any geo statistical analysis. Our study's granularity was at district level, which provides a brief overview of the case. Expanding the work to Taluka, UC and School level can shape a better insight. Socio-economic and political issues may influence the scenario that needs a comprehensive study. Collecting spatial information of all schools along with geographical coordinates may help develop a system in order to combine more aspects of education.

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Improvement of Requirement Elicitation Process through Cognitive Psychology

Sana Fatima, Qamar Uddin Khand, Jawaid Ahmed Siddique
Department of Computer Science, Sukkur IBA, Pakistan
sana.fatima@iba-suk.edu.pk , qamar@iba-suk.edu.pk , jawaid@iba-suk.edu.pk

Zulfiqar Ali Memon
NU FAST Karachi, Pakistan
zulfiqar.memon@nu.edu.pk

Abstract

Proper requirement elicitation is necessary for client satisfaction along with the overall project success, but requirement engineers face problems in understanding user requirements and the users of the required system fail to make requirement engineering team understand what they actually want. It is then responsibility of requirement engineers to extract proper requirements. This paper discusses how to use cognitive psychology and learning style models (LSM) to understand the psychology of clients. Moreover, it also discusses usage of proper elicitation technique according to one's learning style and gather the right requirements.

Keywords: Cognitive Psychology, Learning Style Models (LSM), Requirement Elicitation Techniques

1. Introduction

Software industry is trying their best to build such softwares that earn businesses maximum profit within reasonable cost and time because the technology in market changes quickly. Software engineers with the help of project managers are responsible for building such systems/software that a customer requires. Requirement elicitation is considered as the most critical and most essential part of software development because errors at this stage spread through whole development process and error mitigation at later stages is tough; which might lead to software failure. Users who play important role mostly belong to non IT background, so it is hard for them to express the requirements. Hence, the requirements collected are incomplete, ambiguous and inconsistent. That is why requirement engineers have to understand what users have failed to convey and understand which users can't simply put into words. The quality of the requirements is greatly influenced by usage of proper elicitation technique in appropriate situations. It doesn't prove that the technique which fits with one user might prove to be better for some other user because everyone has their own level of understanding [1].

Often, stakeholders are interviewed about their requirements or asked to write them down, but this approach rarely uncovers the real requirements that reflect a customer's true interests or needs. People have different perception of the world, they think and feel

differently according to their personal experience and preferences [2]**.** On the other hand, there are several other fields which direct requirement elicitation process towards improvement. Cognitive psychology is the field of study in HCI that deals with the thinking mind and is concerned with how we attend and gain information about the world with a goal to develop a theory of intelligent systems [3]. This research study is about mapping elicitation technique that matches an individual's learning style preference or user's level of understanding.

Table 1: Different learning style.

Type of Learner	Preferences
Sensing	Prefers concrete thinking and practicality, concerned with the facts and procedures
Intuitive	Prefers conceptual thinking, innovative, concerned with theories and meanings
Visual	Prefers a visual representation, diagrams, charts, and graphs
Verbal	Prefers written or spoken explanations
Active	Prefers to try new things out, likes working in groups
Reflective	Prefers thinking things out, likes to work alone or with familiar partner
Sequential	Preferably linear thinking, orderly, learn in small incremental steps
Global	Preferably general thinking and systems thinkers, learn in great leaps

"The Felder-Silverman Learning Styles Model" is based on taking learning style into account. While some people say that learning style and educational designs (especially e-learning environments) must accommodate different learning paths. It is great to teach in a way that increases learning for all students. This is challenging because students learn in various ways.

Learners with a strong preference for a specific learning style may have difficulties in learning, if the teaching style does not match with their learning style preference [4].This model grouped people on the basis of how they comprehend information, how they understand better and how their brain works. It divided people on how they prefer information to be presented in front of them. This model further proposed that there are four dimensions of learning styles. It concluded that the teaching style should be adjusted according to specific learning preference of a person which is shown in **Table 1.**

Researcher has used the same idea for eliciting requirements. The idea is to take into account visual-verbal, active-reflective preferences (only two from four) and then chooses a set of stakeholders with particular learning style preference then maps an elicitation technique that fits in accordance with individual learning style preference . This research paper is basically a survey conducted to prove author's point of view.

2. Related Work

A literature review was conducted to explore which authors have worked in the same field. Every author has given their own ideas and proof on how to get a better requirement set using cognitive psychology and some have generally discussed about taking a keen look at elicitation process as whole. Rather than a question and answer session for collecting software and system

requirements, requirements elicitation is more complicated then what it appears to be [5].Generally, the systems requirements identification stage is one of the most important integral parts of the process, that can "make or break" the project. "60% to 80% of errors originate in the user requirements and functional specification" stage [6]. Some authors did relative work using learning style model, their study depicts requirements prioritization where various stakeholders/requirement evaluators are involved. They found out that many conflicts arise in finalizing requirements from a set of already defined requirements, as stakeholders have different knowledge, specialties, and needs of a system. Therefore, reaching consensus on requirement definition is tricky area.

To overcome this situation, they provided a conflict resolution model that considers stakeholders' viewpoints, their work mainly concentrates on defining cognitive weights to priorities requirements. Cognitive weight is a number that represents individual's learning style preference along with elicitation technique he has chosen. The base of their model is goal based method and it is basically a controlled experiment conducted from 24 students of academia who have some experience in requirement engineering processes [1]. Other authors also use cognitive psychology to prioritize requirements. They argue that the requirement engineering should provide a methodological framework applicable to the interpretation and understanding of the terminology used by stakeholders, their views and objectives. That is why Cognitive Psychology provides a conceptual framework, to deal with the descriptions of the stakeholders requirements.

They suggest that stakeholders with same preferences about requirements should be clustered together. They add that it is hard to find out requirements as stakeholders are biased by their owns need so in order to get the requirements that reflects the actual needs can be discovered through the use of semantic memory. In order to get the priority requirements a picture of the stakeholders' semantic memory is to be used as a conceptual structure. Hence their study is about detection of clusters of stakeholders preferences revealed via the Analytic Hierarchy Process (AHP) and the cluster detection is carried out using Self Organizing Maps (SOM) [2], whereas our research study is different from the two above mentioned research studies in a sense that this article depicts how to gather requirements at client site using learning style model, for that a survey was conducted from different requirement analysts in Pakistan and the tool used to prove or disprove hypothesis is SPSS. The only similarity is the usage of cognitive psychology and learning style model.

3. Survey Structure

Sole motivation of this survey is to prove author's opinion on how to find out what a customer actually requires. When it comes to choosing requirement elicitation techniques for clients, there is no particular source on when to use which technique. Requirement analysts usually choose techniques on what they think would suit better in the given circumstances. As a result, requirements gathered are vague and ambiguous. So analyst tend to change the technique once they realize the previous technique failed to grasp the true set of requirements, this has a negative effect on the cost, time and efforts of the overall project.

Author's argument is to choose a technique after finding out the learning style preference of targeted clients, this gives an insight of which techniques are not be used on particular client. So the hypothesis formulated is;

H0: There is no significant effect of mapping Requirement Elicitation Techniques according to people's preferences on getting better requirements set

H1: Mapping Requirement Elicitation Techniques according to people's preferences have positive effect on getting better requirements set

3.1. Survey Design

A survey was conducted to see what techniques are practiced when it comes to requirement elicitation, whether they follow typical bookish techniques or they have their own standard practices, whether they have a solid reason for choosing a technique or not. After that a workshop was conducted for another round of questions and to put forward author's idea and see if it results in better requirement set or not and also to decide which set of techniques to be paired with each preference type, this is shown in Table 2. Random sampling is selected for survey design because initially all of the software houses were selected in Pakistan region, out of which 45 requirement analyst responded and every requirement analyst had minimum of two year experience in the relevant filed.

Survey consisted of a series of questions items and a few interviews. Questions that were asked in first round were about feedback practices in the field and he questions were about, which technique they use mostly, whether they choose a technique on the basis of experience, do they change a technique when they realize the previous technique didn't provide with the required requirements and if the cause of failure is poor communication with the clients and if they want to merge some concepts of psychology with Requirement engineering for better elicitation. In the second round, it was asked to apply set of tasks (mentioned in the section IV.) and see if they find it better to merge cognitive psychology with Requirement elicitation process and help requirement analysts understand stakeholder better and what they suggest should be altered/ added in different elicitation techniques (open ended question).

4. Mapping Learning Style and Requirement Elicitation Techniques

This research process requires requirement engineering team to perform following task when they are at client site for gathering/ discussed requirements. This section was discussed with requirement analyst in the workshop conducted and the tasks concluded were as follows,

Table 2: Elicitation Techniques that are Mapped According to Learning Style Preference

Interview	Reflective People
Ethnography	
Meetings	
Brainstorming	Active people
Focus groups	
Joint application development	
Facilitated sessions	
Scenarios	Verbal People
User stories	
Story board	
Questionnaire	
Data modelling	Visual People
Use cases	
Data flow diagrams/ UML	
Prototyping	

Task 1: Grouping potential stakeholders/end users who directly take part into requirement elicitation.

Task 2: Find out how their brain prefers information to be presented and what is their learning style preference using the index of the Felder Silverman Learning Styles Model which is basically a questionnaire that one has to fill.

After the results, a person can be visual or verbal but not both. And a person can be active or reflective not both. Which means a person can be visual and active, visual and reflective, verbal and active, verbal and reflective and a balanced person with same visual and verbal values and different active or reflective values. Other balanced people include having same active or reflective but different visual and verbal values. And the last people are the ones with balanced choices on both the preferences. So there can be total of seven type of brains people can have.

Task 3: Rank users and categorize them as visual, verbal, active and reflective person according to the results.

Task 4: Choose an elicitation technique that best fits each individual's learning style preference. These techniques are mapped on the basis of characteristics one's brain has.

Mapping was decided in the workshop. The mapping shown in Table 2.

5. Conclusion and Results

This research paper discusses how to improve requirement elicitation process by integrating the Felder-Silverman Learning Styles Model, this model is basically taken from cognitive psychology and is merged with traditional elicitation techniques for getting better requirement set. In order to prove the author's that they choose a technique on the basis of experience which is 71.1%, 40 people said that they change the technique once they realize previous technique failed to grasp true requirements which is 88.9 % and 40 out of 45 said that problems in requirement elicitation.

Claim a survey was conducted. For the first round of questions, out of 45 people 32 said recused by poor communication with the clients which is 88.9 %, the results are mentioned in Table 3. Results were generated using SPSS Results prove that analysts in software houses of Pakistan do not have a solid ground for choosing requirement and due to poor communication they change the elicitation technique when the previous one fails. Second round proves or disproves the hypothesis. McNemar Test was performed with confidence interval of 95% to see if there is any difference in opinions after first and second round of question. The result presented clearly rejects the null hypothesis and proves that merging cognitive psychology with requirement elicitation helps in getting better requirement set. The results are summarized in Table 4.

Table 3: Elicitation techniques that are mapped according to learning style preference

Choose_RET_On_PersonalExperience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	13	28.9	28.9	28.9
	Yes	32	71.1	71.1	100.0
	Total	45	100.0	100.0	

Change_RET_if_Previous_fail

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	5	11.1	11.1	11.1
	Yes	40	88.9	88.9	100.0
	Total	45	100.0	100.0	

Product_failure_problems_in_communication_with_customer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	5	11.1	11.1	11.1
	Yes	40	88.9	88.9	100.0
	Total	45	100.0	100.0	

Table 4: Summarized Result after Applying McNemar Test

Merge_Psychology_with_RET_before * Cognitive_Pstchology_With_RET_After Crosstabulation

			Cognitive_Pstchology_With_RET_After		
			No	Yes	Total
Merge_Psychology_with_RET_before	No	Count	9	25	34
		% within Merge_Psychology_with_RET_before	26.5%	73.5%	100.0%
		% within Cognitive_Pstchology_With_RET_After	81.8%	73.5%	75.6%
	Yes	Count	2	9	11
		% within Merge_Psychology_with_RET before	18.2%	81.8%	100.0%
		% within Cognitive_Pstchology_With_RET_After	18.2%	26.5%	24.4%
Total		Count	11	34	45
		% within Merge_Psychology_with_RET_before	24.4%	75.6%	100.0%
		% within Cognitive_Pstchology_With_RET_After	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	Exact Sig. (2-sided)
McNemar Test		.000[a]
N of Valid Cases	45	

a. Binomial distribution used.

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Optimizing Distributed Machine Learning for Large Scale EEG Data Set

M Bilal Shaikh, M Abdul Rehman, Attaullah Sahito
Department of Computer Science, Sukkur IBA, Pakistan
bilal.shaikh@iba-suk.edu.pk , rehman@iba-suk.edu.pk

Abstract

Distributed Machine Learning (DML) has gained its importance more than ever in this era of Big Data. There are a lot of challenges to scale machine learning techniques on distributed platforms. When it comes to scalability, improving the processor technology for high level computation of data is at its limit, however increasing machine nodes and distributing data along with computation looks as a viable solution. Different frameworks and platforms are available to solve DML problems. These platforms provide automated random data distribution of datasets which miss the power of user defined intelligent data partitioning based on domain knowledge. We have conducted an empirical study which uses an EEG Data Set collected through P300 Speller component of an ERP (Event Related Potential) which is widely used in BCI problems; it helps in translating the intention of subject w h i l e performing any cognitive task. EEG data contains noise due to waves generated by other activities in the brain which contaminates true P300Speller. Use of Machine Learning techniques could help in detecting errors made by P300 Speller. We are solving this classification problem by partitioning data into different chunks and preparing distributed models using Elastic CV Classifier. To present a case of optimizing distributed machine learning, we propose an intelligent user defined data partitioning approach that could impact on the accuracy of distributed machine learners on average. Our results show better average AUC as compared to average AUC obtained after applying random data partitioning which gives no control to user over data partitioning. It improves the average accuracy of distributed learner due to the domain specific intelligent partitioning by the user. Our customized approach achieves 0.66 AUC on individual sessions and 0.75 AUC on mixed sessions, whereas random / uncontrolled data distribution records 0.63 AUC.

Keywords: Data Set, Optimizing, Machine Learning

1. Introduction

Machine Learning is a type of artificial intelligence (AI) that provides computers with the ability to learn real time scenarios from observation data. Based on those observations, models are prepared which can predict unknown outcomes. The consistency of that model helps human in making decisions. Models could be categorized as supervised, unsupervised and also semi-supervised. As the data size, speed and its variety have massively increased we have entered in to an era of Big Data. The

scalability of tools and techniques used for processing large scale data sets have become an active research direction for researchers in Big Data community. To scale machine learning techniques with large datasets it is a common practice to distribute data on several systems, called data nodes. These distributed nodes contribute their computational power and storage to the overall data intensive task.

During a machine learning task, accumulative measure from different working nodes is calculated. This measure dictates the scale of quality of a machine learning prediction.

A. Research Statement: During any cognitive process in human, brain produces some brain activity. Such an activity could be logged through waves generated in the brain. These brain waves could be translated to human intentions of what they want to do. EEG [1] is a device to record such wave data. Data collected through EEG is very noisy with low SNR (Signal to Noise Ratio). Due to this noisy nature of collected data, it is challenging to extract event related potential and interpretation of human intention correctly.

During spelling task, the problem is in detecting errors, which is done through analyzing the brain waves of subject. Differentiating between P300's true and noisy signal is a difficult job. Due to complete paralysis, the patient cannot communicate but it is awake and fully aware. In such a situation, u s i n g BCI (Brain Computer Interaction) a patient can establish contact a channel directly from the brain (signals) to the computer. As EEG signals are very noisy so noise could remove after some important feature extraction from the dataset. Other irrelevant information from the dataset could also be identified to remove noise which will help in analyzing the important part of dataset collected. A learner could be prepared to predict the accuracy of spelling error. As the data set is large and could be distributed among various nodes, we have taken this problem in hand to conduct an empirical study. This study will help us in presenting a proof of concept to below research question.

1) Distributed Machine Learning Platforms provide automated random data distribution/partitioning of data set which neglects the advantage of user defined controlled partitioning of datasets. So if we inculcate domain specific intelligence while partitioning the data for different nodes, will this impact on learner's accuracy?

2. Literature Review

Apache Hadoop is an open source framework for distributed processing and storage of large datasets on commodity hardware. HDFS (Hadoop Distributed File System) is the central technology is designed across low-cost commodity hardware and for the efficient scale out storage. HDFS is responsible for providing reliable and scalable data storage that deals with span of large clusters of commodity servers [3]. Hadoop implements the Map Reduce [4] computational paradigm and using HDFS as its compute node.

HDFS is a distributed file system designed to run on commodity hardware [5]. HDFS key feature is it's highly fault tolerant behavior. HDFS is designed for deployment on low-cost commodity hardware. HDFS is also good for providing high throughput access to application data and is quite suitable for applications that have large volume of data.

GFS was designed by Google [6] to support the similar goals as previous distributed file system have like HDFS [5] performance, scalability, reliability and availability. Google File System has been driven by observations Google made to meet their storage needs. Google File System presented new extensions to existing distributed file systems keeping various aspects for both micro-benchmarks and real world use.

MapReduce [4] is a paradigm shifting programming model for processing

large datasets dealing with parallel distributed algorithm. In map reduce user defines the computations as map and reduce functions and the underlying run time system automatically parallelizes the computation across the large-scale clusters of machines, possible machine failures and schedules other inter-machine communications to make the possible efficient use of the network and disks.

Graph Lab [7] was developed by identifying common pat- terns in ML, it is a parallel abstraction that achieves higher usability, expressiveness and performance. Unlike previous parallel abstractions, Graph Lab offers representation of structured data dependencies, iterative computation, and flexible scheduling. It uses data graph to encrypt the computational structure and data dependencies of problem. It represents local computation as update functions which transform the data on the data graph. Because these update functions can modify overlapping state, the Graph Lab framework provides a set of data consistency models which allow the user to specify the minimum consistency requirements of their application. Spark [8] is a new framework that supports applications that are not focused around acyclic dataflow model retaining the scalability and fault tolerance of MapReduce.

Spark introduces a new layer of abstraction called Resilient Distributed Data Sets (RDDS). An RDD Set is a collection of objects partitioned and read only across a group of machines which reestablishes itself when a partition gets lost. Spark author claims to outperform popular Hadoop by 10 times in iterative machine learning jobs, and highly efficient for interactive query processing to large scale datasets than existing frame-works.

Petuum is a recent framework for distributed Machine Learning [9], the development of Petuum is based on a theoretic ML-centric optimization principle. Petuum formalizes ML algorithms as iterative convergent programs which encompass a larger scope of modern machine learning like MCMC, stochastic gradient to estimate points in latent variable models, coordinate descent, proximal optimization for structured sparsity problems, variation methods for graphical models, among others. Petuum authors claim it to be better than existing ML platform. Petuum displays better performance for being an alternative to single machine algorithms CNN, Caffe and DML [9].

3. Research Methodology

For setting up development environment for the sake of proof of concept, we have used Spyder IDE (Integrated Development Environment) for Python-based development. For using Machine Learning techniques SciKit Learn library [10] was used. ElasticNet API (Application Programmable Interface) provided the implementation of ElasticCV classifier. Numpy [11] was used to partition data into the two-dimension dataset into multiplied is joint 2D datasets. For plotting the ROC graphs of classifiers ggplot [12] is used.

We have a 9.5 GB EEG raw dataset which was selected to conduct empirical experiments. The purpose of collection of data was to predict the error in spelling correction from p300 speller which was used by Perrin et.al [13]. An experiment was carried out over nine different subjects with five sessions each. These five sessions are assumed to be an Epoch window, i.e. a dataset within a time frame which is collected after each stimulus. These Epochs will then processed as training dataset to the classifiers. Perrin [13] has presented an explanation about the configuration of EEG device was used with the subjects.

Dataset contains both training data as well as data for testing of learners. Training dataset consists of 16 subjects while testing dataset comprises 10 subjects; each had attended 5 disjoint sessions on spelling. In master dataset, total trials for training were 5440 and 3400 were test trials. There are two labels of data, (i) Target and (ii) Non-Target.

In preprocessing phase shown in Figure 1.0is regarding EEG signal data, EOG channel was removed implemented in python. EOG (Electro Oculo Gram) channel produces information introduced by the blinking of eye which is a noise in our case. Then, butter-worth filter between 1-40Hz band pass filtered the EEG signals is applied. Butter-worth is also known as maximally flat magnitude filter. Only 1.3 seconds is set for Epochs which is after the occurrence of any possible stimuli or feedback event by the subject. Then feature extraction is applied before the classification. Only preferred electrodes are selected within a recommended time of 1.3 seconds

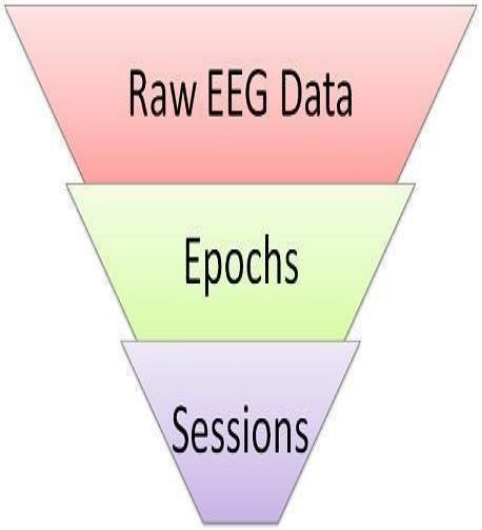

Figure. 1: Pre-processing Workflow from Raw Data Set to Sessions Based Data Partitions

Window later concatenated with Meta data. Data size got reduced. A total master dataset with 5440 instances having 2211 dimensions became available for further processing. The EEG based Feature extraction is done as per the following methods:

1) Dawn Covariance: Two sets of 5 XDAWN spatial filters are estimated, one for each class (Error and Correct). The grand average evoked potential of each class is then filtered by the corresponding set of spatial filters, and concatenated to each epoch. The covariance matrix of each resulting epoch is then used as feature for the next steps [14].

2) Electrode Selection: A channel selection is applied to keep only relevant channels. The procedure consists in a backward elimination with the Riemannian distance between the Riemannian Geometric mean of the covariance of each class as the criterion.

3) Tangent Space: Reduced Covariance matrices are then projected in the tangent space [15]

4) Normalization: Feature Normalization using al1 norm. Epoch windows which was partitioned on the basis of different sessions attended by subjects into five disjoint datasets. This partitioning is totally data dependent, unknown to machine learning learners and underlined infrastructure. This could be called as user defined data partitioning.

A new dimension was added to the dataset to categorically divide it. This dimension labeled each instance with the respective session ID of that instance. All the labeled data was extracted later in order to achieve different sub datasets. These sub datasets could be distributed to different nodes and processed in parallel in case of speeding up the process. Our goal is to focus on optimization in accuracy of learners. Therefore, speeding up the performance is not the important concern here.

4. Classifiers Based on User Defined Intelligent Data Partitioning

Now as the trained dataset is ready after partitioning to train multiple distributed classifiers. So, each learner has its own dataset which has been partitioned as per respective session of the subject. These disjoint partitioned datasets are used for acquiring knowledge about the parameters using

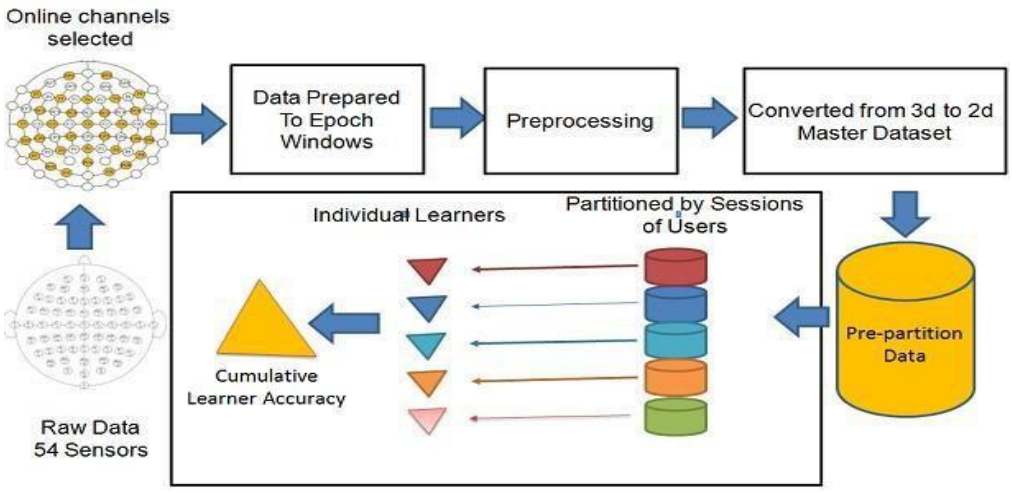

Figure. 2: Overall Work Flow: From Pre-processing to Classifier Preparation of the subject.

ElasticNet. ElasticNet overcomes limitations of lasso and ridge regression, it is linear regularized regression algorithm and works well with numerical attributes. Elastic can formulate our problem. Five different classifiers are built individually for each disjoint dataset. As all partitions are based on sessions taken by each subject. This complete workflow is shown in Figure 2.0. Therefore, this controls the partition data as per prior knowledge enabled by the user to define its own data partition for each classifiers training. Each case classifier is not only trained to predict the expected error in user session but it will also help the observer to notice the behavior of user customization which is based on systematic knowledge of the domain. Not incorporated in map reduce paradigm [4].

5. Classifiers Based on Traditional Hdfs like Data Partitioning

On the other side, another five learners are built which are trained on randomly partitioned dataset which is a behavior of HDFS [3] where control over data partitions is not provided. These learners are developed to cross validate against our customized learners which have been injected the user defined domain specific intelligence. Although their data sizes are similar and the instances contained within these disjoint randomly partitioned datasets are different to random distribution.

6. RESULTS

The observed results from the conducted experiments that were described in previous sections are presented here. The observations about the accuracy trends are noted along with the results. First results are shown as per our proposed customized user defined intelligent partitioning and then the results are compared with the platform controlled random like data partitioning used with most distributed machine learning solutions like [17] by NDjuric.

7. Analysis of Results

Experiments were run on all data that after mapping the space from 3-D to 2-D space to make it compatible with ElasticNet classifier. First of all, we are going to analyze how well our approach performs, for this we

have used average of areas under ROC curve as measure for accuracy, as it is commonly used in the field of BCI. In ROC [18], [19] curve AUC (Area under curve) determines the credibility of classifier clearer than [4] just scalar metrics. ROC curves along with their AUC for individual sessions based of intelligent data partitioning is shown in Figure 3.

In ROC curve, which is TPR versus FPR, different graph representing different models are showing the impact of data. A variation in ROC Curve can be observed easily. However, every session's data has its own effect towards the creation of respective learner. To get the overall effect of sessions feature towards the accuracies we have average all five accuracies. Our measure of average area under curve for our intelligently partitioned dataset based models is 0.66 for the whole test data set, which shows better performance of models. ROCs could also be combined by aggregating [17] or collecting global sum of accuracies [20].

8. Comparison with Traditional Approach

To explore how well our customized partitioning approach performs, we have compared our approach average model accuracy obtained after random partitioning of data as done HDFS which takes back the control of underlying data distribution on different nodes from the user [5]. Testing data is randomly sampled into 5 sets, each of similar size of trials as it was for our custom partitioned data sets.

A. AUC Comparison: We compared the ROCs obtained from partitioning datasets as per user defined session based intelligence against the ROCs obtained after partitioning the data set in traditional way of HDFS. In both cases, we obtained five learner accuracies which we combined by taking average of each set. After aggregation of accuracy the Average Accuracy in User defined with intelligent partitioning resulted approximately 66 percent obtained from iindividual session based accuracies shown in Figure 3.0. While the average of accuracies obtained from traditional HDFS [5] way of partitioning obtained was around 63 percent. This shows an overall improvement of 3 percent in combined learner's accuracy. If user observes other important features in the data set or empirically test the variation in learner's performance the same data set, Accuracies [21] of Machine Learners could be tweaked at a large span.

9. Conclusion

This research work proposes Intelligent Data Partitioning with test case taken from a BCI P300 speller error detection problem. This approach has shown results that are improving learner's accuracy on even

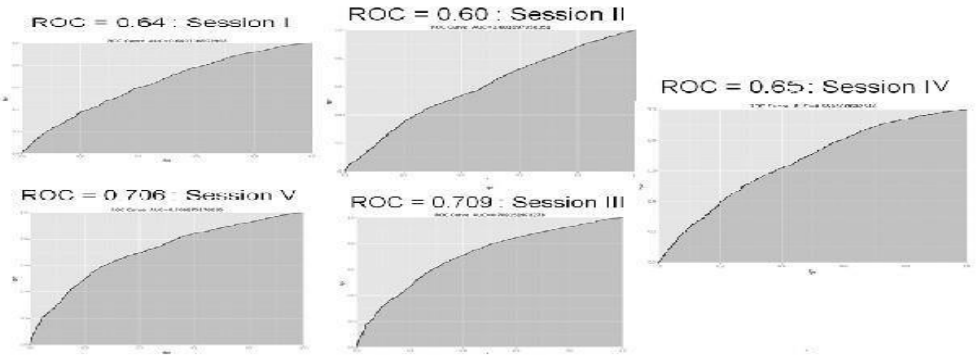

Figure. 3: Area Under ROC Curve of the classifiers from Individual Session

average aggregation. The impact of observers' intelligent data partitioning would increase with higher relevance of partitioning feature. More efficient feature engineering and nature of dataset could also improve the results. Such a type of optimization in distribution machine learning results could also expose other key insights about features of data that are only specific to a domain. This entails that allowing user controlled data partition- in will enable the analyst to dig deeper into the process of efficient machine learning. As per observed results of our proposed approach; the system performs relatively efficient for classification of the selected EEG signals in terms of average AUC in intelligent data partitioning scenario having better results. There is visible evidence for comparison based on average ROC to build a combine decision model while keeping a data attribute under control for AUC. Our proposed approach demonstrates a relatively better AUC in phase of testing supplied with low amount of data for training.

We conclude that our proposed approach will be effective if applied in other machine learning scenarios we could gain even better Average AUC and it could perform better during the other inter-features variability.

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