Remote Patient Monitoring during pandemic caused by COVID-19 using Semantic Web Technologies

Moumita Pal, Ranjana Ray, Prasenjit Maji, Antara Panja

Mail id: moumita.pal@jiscollege.ac.in

1 Assistant Professor, JIS College of Engineering, ECE Department, Kalyani, INDIA, 741235
2 Assistant Professor, Bengal College of Engineering and Technology, CSE Department, Durgapur, INDIA, 713212
3 Student, JIS College of Engineering, ECE Department, Kalyani, INDIA, 741235

Abstract: Data integration facilities along with decrease in the quantified operational health information occurs due to stuck in hospital admission. Exchanging of information resources has an immense significance due to 3 critical capabilities. These can be enlisted as information swap over through electronic connectivity, interoperability, and compromising under prescribed medication, in which automated systems are involved to solve pathological discrepancies. Along with all these concern about patient safety is taken care of by this strategy. The substantial awareness can be resulted in computational methods and tools which are quite capable for rendering guidance to health care services more resourcefully, which further leads the advancement and execution of intellectual systems within the therapeutic domain. Exchanging of data in the Web can be complies with Resource Description Framework (RDF) and ontology’s. RDF has the capability of capturing information content instead of considering the syntax. Inferential support and transformational approach is feasible by deploying RDF. Facilitation of data by evolution and merging phenomenon can be utilised by the involvement of RDF though schemas variation exists. Semantic interoperability is achieved either by applying standardisation or by translation. Though standardisation is quite acceptable but due to time annihilation transformation in lieu of modernisation is acceptable more. Strategically, realistic approach of semantic interoperability comprises both standards and translations. Conceptual classes, their interrelations, instances and axioms exist in Ontology.

Key Words: Web Semantics, Ontology, Resource Description Frame Work

1. Introduction

This research work deals with a realistic strategy for semantic interoperability which addresses both standards and translations. The facilitation involve in Semantic Web and Cloud Technologies are also explored in this context for developing a patient monitoring system to extend support towards the medical practitioners. Filtering is done quite intelligent manner with substantiation associated with knowledge and extensively information to distinguished individual that can be provided through treatment notifications and functional tests at suitable times or according to recommendation. Architecture is proposed as back-end part in accumulation with platform based on cloud for IoT, combining intelligent systems with patients’ regular schedule and medical support [1]. In clinical support system interoperability within various terminologies is required the most. The annotations in biomedicines and numerous datasets are accumulated and exchanged. Various standardisation
organisations have recommended [2] different standardisations in the time of prescribing. As an example, the Department of Veterans Affairs in the United States has recommended National Drug File - Reference Terminology (NDF-RT), International Health Terminology Standard Development Organization (IHTSDO) did the same as SNOMED CT [3][4]. Reconciliation is quite difficult in this case as in terminological system various drugs are available which are having least overlapping sections. Due to the involvement of SNOMED CT, NDF-RT, RxNorm, overlapping with other terminologies is reduces and good coverage takes place in clinical drugs. Annotation of drugs is quite relevant compared to pharmacological terms in semantic mining [5]. After inclusion of resources at the ingredient level, the consequent classes are accumulated later on as per the relevant pharmacological class. Thus presence of numerous standards requirement of a universal standardisation is quite obvious in this regard.

Acquiring sufficient amount of necessary and relevant information can build up a better health care monitoring system for a patient [6]. Various information is integrated from numerous sources and organizations. It’s a great challenge for the industry to take care of these data in proper manner. Usage of multiple vocabularies, different media, prototypes, and implemented systems are quite responsible for materializing this challenging job into reality. Preferably, sharing and exchanging of information related to electronic healthcare is done using Resource Description Framework (RDF) or involving standardised format that can be mapped to RDF [7][8]. Exchange of accessible standard healthcare idioms, data prototypes and vocabularies should be expressed by converting those into standard mappings to RDF, and any acceptable new formats having RDF representations. In lieu of this context, usage of RDF as a globally accepted exchange language has been made a mandatory initiative by all government agencies[9]. Various government agencies. Linked data doctrines are made in a form of self describing method for exchanging healthcare information.

Since then, the Yosemite Manifesto has accumulated a large no of signatures from the Semantic Web community[10], medical persons, researchers, and professionals from various sectors involved in healthcare sector. In order to mitigate this challenge, development of efficient, dedicated and disseminated health systems is quite necessary[11]. Along with it, high quality and feasibility of sustainable health care monitoring system is also needed to be increased. This requirement also justifies its requirement in developing countries for enhancing the communication and cooperation between all ethics and ideologies involved in dealing with patients [12]. System characterization by blending with intrinsic scientific research and technical expertise and containing better impact on societal along with its environmental impact, requires communication between different actors requires open, adjustable, extensible, alignment with service, smart, semantically interoperable, and effective information systems. To mitigate the necessity for analyzing, designing, implementing and evaluating [13][14], a common format is needed to maintain this type of health care information system. Universally accepted procedure in health information systems (HIS) is developed depending on domain specific criteria. In view of this, the accumulation of masterpiece and disintegration of the systems components is not only responsible for formation of module architecture rather its dependency also lies on the tools deployed in this system [15]. In this chapter, a framework is developed based on principles and strategies which deals with certain methodologies and technical procedures to be engaged in this method for preparing and realizing semantic interoperability in proposed health information systems and also can be utilized for provide better service to public health [16]. As a state of art proposes an architectural development towards information system,
hence the system architecture should be examined and synchronized with the framework. To achieve this phenomenon, documentation, methodology for performing tasks, authorization of personnel, artifacts, licensed products and process flow should be defined in a standard format [17]. This particular process is based on defined engineering techniques which include formal software of updated version defined by resource description framework. This framework incorporates a flexible process along with measurable approach and uploaded in various web resources in HTML pages or shared as various web supported file formats.

2. Background and literature survey

In the huge extent of healthcare environments, interoperability is a prime requirement in various applications for information sharing. Various systems provide data in different format and thus are really tough to integrate and also to develop cross-domain application as various protocols are involved there for extraction and processing of data [18][19]. Along with it usage of different formats for data management and terminologies also leads to a problematic situation for exchanging this information for health care. Unless generalised agreed formats with proper standardisations will be maintained all over the world, appropriate interoperability level can’t be achieved in well manner.

Using similar models, sharing and interchanging of data got hampered, hence to interoperate the concepts the models are differed from one another [20]. In this context interoperability is highly essential as semantic interoperability provides a universal version of the meaning related to the content for different systems. As a result, diversified systems can easily be integrated and cooperated based on semantic models [21].

2.1 Standard ontology models

In some cases, standard ontology models are involved where in other cases approaches are engaged by semantic alignment to mitigate heterogeneous healthcare system. Semantic ontologies extends a semantic link for various applications as the vocabularies used in this ontology [22], are quite capable of defining the domain concepts and explore the implementations on academic institutions and industries. Involving smart devices, various sensors have been introduced by Commonwealth Scientific and Industrial Research Organization (CSIRO). Another organisation named as Sensor Web for Autonomous Mission Operations (SWAMO) enables the integration of agents in intelligent environment using web of sensor. Another approach mostly used in invasive environments is W3C Semantic Sensor Network (SSN) that deals with different sensors, actuators, explanations, salient features, methodologies and samples [23]. Due to variation in human perspective regarding their domain knowledge, numerous ontologies exist and this creates difference among each other during explanation of same domain concepts. This situation can be dealt with involving ontology alignment for supporting semantic interoperability [24]. In ontology alignment, one to one mapping is established among the concepts and relationship of the ontologies. Structural and terminological alignment along with similarity based concept is utilised for sharing external information. In automated ontology alignment based procedure, complex ontologies are handled by RDF and ontology Web Language(OWL).
2.2 Prototype of data interoperability

The semantic interoperability considers general semantic architecture and methodologies to share the required data through semantic mediation while exchanging the integrated form of data. As the mechanism provided by semantic mediation deals with isolated and generalized data management procedures, so, development of semantic interoperability model arises some provisions of concepts related to metadata and its alignment with target domain [25]. The first and foremost requirement of this kind of mechanism is only to achieve an efficient and consistent interoperability for healthcare application. A prototype of data interoperability is shown in figure 1 for efficient and effective healthcare information system. Several hospitals, centres for clinical psychoanalysis, institutions (Government sponsored or aided), medical organisations come together to imitate a generalised format for data sharing by mutual decision making. Variety of healthcare applications are quite beneficial for understanding of shared data, faster generic, cost reduction and lastly decrement of complexity arose by data management. Data interoperability is equally beneficial in the increasing scenario of diversified application such as global healthcare market, telehealth solutions, diagnosis and consultation application, clinics, applications oriented with health information interchanging and lastly healthcare management related to chronic disease [26].

As shown in fig. 2 We represent our idea for developing an advanced design of an automated and smart patient-care arrangement. Here sensors are associated to the client who are connected through Internet and all actions and conditions are displayed in the monitor. IoT and cloud computing open up a modern technology based system, still, due to health principles, set of laws and formats for transferring and analyzing health data to the cloud is really a matter of concern.
3. Design of a Cloud Deployment Model

Blending of programming with the information stored in cloud platform provide layout for the software application development related to cloud and involves sensitive data. These requirements of a global Health utilize the technology that involves software application for transferring the data at nearby resources. This developed architecture provides the requirement of designed skeleton to set aside cloud services where clients can make the initiation but hosting will be pursued through a private cloud. This projected framework will emphasize the hypothetical model of FI-STAR by representing a cloud platform structural design without any sensitive data that will be altered but will be a feature at the back-end site.

3.1 Front-End System

In collaboration with patients’ fitness report, analytical observations, and experimental guiding principles, various kinds of artificial intelligence based smart monitoring tools are developed which includes temper charting, life enlisting, antipsychotic and lithium monitoring can come up with sustainable aspects of patients’ daily life.

A novel approach is represented in this research work that assist to develop a heterogeneous medical information depository and sustain involving variety of input-data from patient’s health report and observation chart based on computerized monitoring device or smart devices. Various health care monitoring system involved these electronic monitored system as stated below.

3.2 Back-End System

The back-end system is implemented using the FI-WARE platform, that expresses the stipulation along with designing accessories to develop original applications and services based on cloud. The later inculcates basic activity blocks, named as Generic Enablers (GEs) which includes both client and software program based substantiation, background data administration, data capturing and information inclusion in the FI-WARE catalogue. Inclusion of interfacing with the supplier which indulge into a variety of modular systems related to the perception for communal cloud. Confidentiality of the clients in the cloud site in collaboration with the back-end module, mitigate the usage of experimental software applications that are installed for hypothetical monitoring site. Network that deals with operations related to internal connectivity that permits communication among client front end with the medically diagnosed data.

4. Overall system environment

A smart patient care system structural design is presented in this research work using Semantic Web and cloud computing technologies that gives clinical and physical conditions with a set of operations. Certain illustrations related to treatment, suggested examinations, and warnings for certain fluctuations of patient’s condition for non-response to treatment, astutely evaluated and visible in proper time. We anticipate a module that deals with extensively distributed consumers which indulge the utility of monitoring devices that develops human mental health monitoring. Fig. 2 shows the high level functionalities of the monitoring system prototype.
4.1 Proposed Algorithm

Step 1: Accumulation of Data from the client end by involving intelligent systems and sensing devices for retrieving of neighboring data.

Step 2: Interfacing between the back-end system by permitting interconnectivity facilities from the front-end applications.

Step 3: Announcement of the facilities to enter statements and set notifications to any fascinated clients and medical practitioners.

Step 4: Characterization of patients’ integrated and analyzed data with the requirements of the treatment such as patients having bipolar disorder, high fever, breathing trouble etc.

Step 5: Protected data storing within the cloud to encrypt patients’ information.

Step 6: Adoption of system module inheritance for data transmission among the neighboring systems and various modules.

Figure 2 Overall System Architecture of the designed monitoring system using cloud and semantic web technologies

The data base generated by the system and is used by the integrated platform to hold the information data. The data is kept neutral and independent from the other sources offering improved scalability and performance. The design of the database was based on information provided by the define architecture and that particular information’s are used to monitor the condition of the patient.

5. Conclusion
Demonstration of utilizing semantic web permits drawing of methodical information and ontology formation by characterizing patient details and segregation of principles based on circumstantial proofs that leads to notify and recommend for personalized data analysis and medical advices. Demonstration by employing cloud model for an highly developed perspective that helps to monitor chronic and acute diseases and genetically transmitted disorders.

A fundamental architecture proposed which is based on a cloud platform. Justification for examining the patients disease are executed gradually for the realization of direct implementation to a chosen sample of critical cases. As future work, cloud-based architectural application through a practical data acquirement is performed from sensing devices and wearable devices, which will be transmitted to the cloud platform for analyzing and monitoring patients’ based on well explained pre-defined standards for exchanging data.

References

[1] I. Chiuchisan, and O. Geman, “An Approach of a Decision Support and Home Monitoring System for Patients with Neurological Disorders Using Internet of Things Concepts,” WSEAS Transactions on Systems, vol. 13, pp. 460-469, 2014.

[2] U. Varshney, “A Framework for Wireless Monitoring of Mental Health Conditions,” in Conf. Proc. EMBS 2009 IEEE 31st Annual International Conference, pp. 5219-5222.

[3] B. S. Shastry, “Bipolar disorder: An Update,” Neurochem. Int., vol. 46, no. 4, pp. 273-279, 2005.

[4] G. Valenza, C. Gentili, A. Lanata, and E. P. Scilingo, “Mood Recognition in Bipolar Patients Through the PSYCHE Platform: Preliminary Evaluations and Perspectives,” Artif. Intell. Med, vol. 57, no. 1, pp. 49-58, 2013.

[5] P. Prociow, K. Wac, and J. Crowe, “Mobile Psychiatry: Towards Improving the Care for Bipolar Disorder,” Int. J. Ment. Health. Syst., vol. 6, no. 1, pp. 5, 2012.

[6] J. Alvarez-Lozano, V. Osmani, O. Mayora, M. Frost, J. Bardram, M. Faurholt-Jepsen, and L.V. Kessing, “Tell Me Your Apps and I Will Tell You Your Mood: Correlation of Apps Usage with Bipolar Disorder State,” in ACM Proceedings 7th International Conference on Pervasive Technologies Related to Assistive Environments, Rhodes Island, 2014.

[7] K. R. Connolly, and M. E. Thase, “The Clinical Management of Bipolar Disorder: A Review of Evidence-Based Guidelines,” Prim. Care. Companion CNS Disord., vol. 13, no. 4, pp. PCC.10r01097, 2011.

[8] T. Berners-Lee, J. Hendler, and O. Lassila, “The Semantic Web,” Scientific American, pp. 28-37, May 2001.

[9] G. Antoniou, and F. Harmelen, “Web Ontology Language: OWL,” Handbook on Ontologies, 2004.

[10] I. Horrocks, P. F. Patel-Schneider, H. Boley, S. Tabet, B. Grosof, and M. Dean, “SWRL: A
semantic web rule language combining OWL and RuleML,” W3C Member Submission, May 2004.

[11] S. Hussain, and S. S. R. Abidi, “Ontology Driven CPG Authoring and Execution via Semantic Web Framework,” in Proceedings 40th IEEE International Conference on System Sciences, IEEE Computer Society, Hawaii, 2007.

[12] E. Sanchez, C. Toro, E. Carrasco, P. Bonachela, C. Parra, G. Bueno, and F. Guijarro, “A Knowledge-Based Clinical Decision Support System for the Diagnosis of Alzheimer Disease,” in Proceedings 13th IEEE International Conference on e-Health Networking, Application & Services, Columbia, MO, 2011, pp. 355–361.

[13] J. S. Deogun, and W. Spaulding, “Conceptual Development of Mental Health Ontologies. Advances in Intelligent Information Systems,” Studies in Computational Intelligence, vol. 265, pp. 299-333, 2010.

[14] N. Noy, and B. Rector, “Defining N-ary Relations on the Semantic Web,” W3C Working Group Note, April 2006.

[15] S. Batsakis, and E. G. M. Petrakis, “SOWL: A Framework for Handling Spatio-temporal Information in OWL 2.0,” in RuleML Europe, ser. Lecture Notes in Computer Science, Springer, 2011, vol. 6826, pp 242–249.

[16] Mell P, Grance T, “The NIST definition of cloud computing,” Commun. ACM., vol. 53, no. 6, pp. 50, 2010.

[17] A. M. Kuo, “Opportunities and challenges of cloud computing to improve health care services,” J. Med. Internet Res., vol. 13, no. 3, pp. e67, Sep. 2011.

[18] L. N. Yatham, S. H. Kennedy, S. V. Parikh, A. Schaffer, S. Beaulieu, M. Alda, C. O'Donovan, G. Macqueen, R. S. McIntyre, V. Sharma, A. Ravindran, L. T. Young, R. Milev, D. J. Bond, B. N. Frey, B. I. Goldstein, B. Lafer, B. Birmaher, K. Ha, W. A. Nolen, and M. Berk, “Canadian Network for Mood and Anxiety Treatments (CANMAT) and International Society for Bipolar Disorders (ISBD) collaborative update of CANMAT guidelines for the management of patients with bipolar disorder: update 2013,” Bipolar Disord., vol. 15, no. 1, pp. 1-44, Feb. 2013.

[19] H. Grunze, E. Vieta, G. M. Goodwin, C. Bowden, R. W. Licht , H.-J. Moller, S. Kasper and WFSBP Task Force on treatment guidelines for bipolar disorders, “The World Federation of Societies of Biological Psychiatry (WFSBP) Guidelines for the Biological Treatment of Bipolar Disorders: Update 2009 on the Treatment of Acute Mania, The World Journal of Biological Psychiatry, vol. 10, no. 2, pp. 85-116, 2009.

[20] National Institute for Health and Care Excellence, “Bipolar disorder: the assessment and management of bipolar disorder in adults, children and young people in primary and secondary care,” National Institute for Health and Care Excellence, NICE clinical guideline 185, Sep. 2014.

[21] Royal Australian and New Zealand College of Psychiatrists Clinical Practice Guidelines Team for Bipolar Disorder, “Australian and New Zealand clinical practice guidelines for the treatment of bipolar disorder,” Aust. N. Z. J. Psychiatry, vol. 38, no. 5, pp. 280-305, May 2004.

[22] G. M. Goodwin, Consensus Group of the British Association for Psychopharmacology. Collaborators: S. Chandler, I. Anderson, F. Colom, D. Coghill, J. Cookson, N. Ferrier, J. Geddes, G. Goodwin, P. Haddad, N. Hunt, N. Kapur, I. Jones, D. Lam, A. Lingford-Hughes, D. Miklowitz, R. Morriss, B. Sahakian, J. Scott, D. Taylor, J. Thakore, A. Thapar, A. Thomas, P. McGuire, S. Cooper, P. Cowen, C. Manning, K. Ebmeier, J. Cavanagh, T. Barnes, and K. J. Aitchison, “Evidence-based guidelines for treating bipolar disorder: revised second edition-- recommendations from the British Association for
Psychopharmacology,” J. Psychopharmacol., vol. 23, no. 4, pp. 346-388, June 2009.

[23] G. Heja, G. Surja, and P. Varga, “Ontological analysis of SNOMED CT,” BMC Med. Inform. Decis. Mak., vol. 8, no. 1 (Suppl), pp. S8, Oct. 2008.

[24] M. Moller, D. Sonntag, and P. Ernst, “Modeling the International classification of diseases (ICD-10) in OWL,” in Second International Joint Conference 2010 Knowledge Discovery, Knowledge Engineering and Knowledge Management, pp. 226–240.

[25] B. Smith, and P. Grenon, “The Cornucopia of Formal Ontological Relations,” Dialectica, vol. 58, no. 3, pp. 279-296, 2004.

[26] S. Schulz, H. Stenzhorn, M. Boeker, and B. Smith, “Strengths and limitations of formal ontologies in the biomedical domain,” Rev. Electron Comun. Inf. Inov. Saude, vol. 3, no. 1, pp. 31-45, March 2009.