Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 21s (2025)
https://www.jneonatalsurg.com
OPEN ACCESS

Designing Effective Intelligent Healthcare Application Using Internet of Behavior

Dr. Rasika Mallya

Associate Professor, MCA, DES's Navinchandra Mehta Institute of Technology and Development, Dadar (W), Mumbai.
Email: rasika.mallya@despune.org

Cite this paper as: Dr. Rasika Mallya, (2025). Designing Effective Intelligent Healthcare Application Using Internet of Behavior. *Journal of Neonatal Surgery*, 14 (21s), 979-985.

ABSTRACT

The Internet of Behavior (IoB) focuses on understanding human behavior and using that understanding when designing smart software. It connects digital technology with how people act, so that software can be created and improved based on real human behavior. Basically, IoB uses data to find patterns in what people do, helping to make technology more human-centered. This paper explores the integration of the Internet of Behavior (IoB) with Engineering of Complex Adaptive Systems to design Intelligent Healthcare Application that boost user engagement and improve health outcomes. It also discusses how to build smart design features into systems using IoB. Further, this study applies IoB conceptual model to Assistive Healthcare System to identify human components and related system components. The model also identifies expected and real behaviour of human components. These behvaiours are mapped with runtime adaptation of requirements. The proposed model's primary objective is to capture human behavior, create a model based on it, and build a system that can adapt to changes in real time, learn continuously from repeated actions, and build a growing base of knowledge. The effectiveness of the proposed model is checked with Technology Acceptance Model (TAM). This paper presents role of IoB in bringing design intelligence and adaptive nature in intelligent system.

Keywords: *Internet of Behavior, Complex Adaptive Systems, Intelligent Healthcare Application, Technology Acceptance Model.*

INTRODUCTION

The Internet of Behavior (IoB) is the fusion of technology, data analytics and behavioural science. It refers to gathering and applying data to influence behaviour. This data is gathered by electrical appliances, personal internet activities and wearable technology. IoB is an extension to IoT that utilizes data captured from IoT devices to use feedback loops to affect customer actions and behaviour. The Internet of Behavior (IoB) connects digital systems with human actions, preferences. It creates balance between Quality of Experience (QoE) with Quality of Service (QoS) to create more personalized and efficient interactions. IoB monitors human behavior, adjusts itself based on what it learns, and influences people's decisions explicitly and implicitly. The Internet of Behavior is formed based on following principles: i. Designing intelligent ubiquitous system based on IoT infrastructure which monitor and predicts human behaviour ii. Adapting the system to current behavioural patterns iii. Influencing people's choices and behaviors in specific context. [1]

The Internet of Behavior (IoB) enables healthcare professionals to gather data and understand patient behavior, leading to more effective treatment. IoB is helpful for healthcare industry to deliver individualized care[2]. Body sensor networks with particular wearable sensors are used by assistive healthcare systems to track physiological characteristics. People-centric sensing are used in assistive healthcare systems to track individuals' health metrics for treatment, disease diagnosis, or potential health issues or to evaluate how well treatment is working. People-centric sensing, also known as participatory sensing, is a method of involving people in order to collect different kinds of sensable characteristics in the field of personal healthcare. Assistive healthcare systems is made adaptive with Case Base Reasoning methodology, opportunistic sensing approach. With opportunistic sensing approach the system becomes responsive to new situations by collecting samples or sensing more physiological parameters to make case base strong and The CBR methodology continuously upgrades the system with recent cases [3]

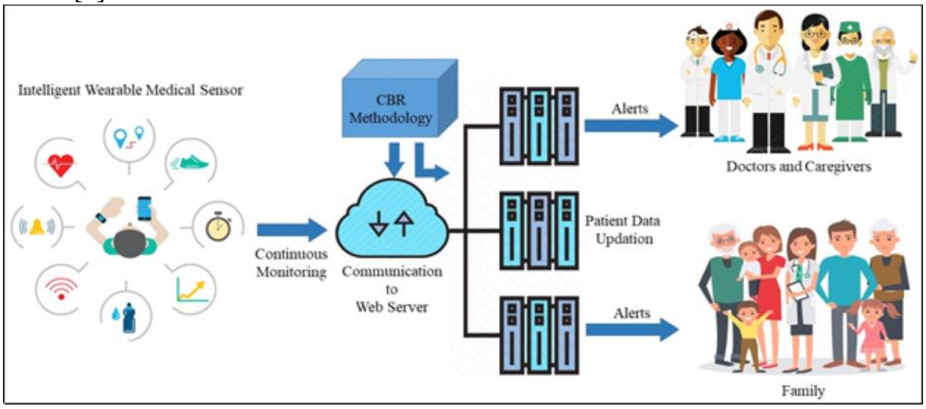

Figure 1: Adaptive Assistive Healthcare System with Opportunistic Sensing

This paper focuses on integration of concept of Internet of Behavior (IoB) with Adaptive Assistive Healthcare System to make the application more effective with Quality of Experience (QoE) and Quality of Service (QoS). The effectiveness of proposed system is checked with technology acceptance model (TAM) with two approaches : perceived usefulness and perceived ease of use. [4]

The questions and contributions which are addressed in this paper are:

RQ1: *How IoB can bring the intelligence in the system at design level?* For this, the relevant literature is reviewed and simulation of Internet of Behavior workflow in any application and role of IoB to bring intelligence in system at design level is explained. To explain this, example of Assistive Healthcare System is considered with the aim of making it adaptive and intelligent. (Section II)

RQ2: *How IoB conceptual model is applied to any system and how to check effectiveness of the system?* For this, IoB conceptual model is applied to Assistive Healthcare System studying different components of mentioned system. Technology Acceptance Model is applied to proposed model to assess effectiveness of proposed system.

Section IV concludes the study with conclusion.

1. LITERATURE REVIEW

2.1 Internet of Behavior (IoB):

Wearable technology is being used by IoB to gather vast amount of data on human behavior and transform it into insightful knowledge that can be used to alter user preferences, interests, and behavior in order to enhance the user and search experience. IoB aims to properly comprehend data and apply this comprehension to develop new products, market existing items, restructure the value chain, boost revenue, or cut expenses from a psychological perspective. The workflow of IoB in any IoT application is as shown in figure 2.

i. **Track:** User behavior in the IoB workflow will be tracked first using connected devices.

ii. **Collect:** The data generated by IoT devices will be collected on cloud storage.

iii. **Analyze:** The monitored data is analysed using data analytics and machine learning algorithms to extract useful information.

iv. **Understand:** The analysed data will be understood properly from a behavioral science perspective.

v. **React:** Finally, the knowledge gained will be used to develop business strategies and influence the behavior of users, thus achieving certain outcomes. [5]

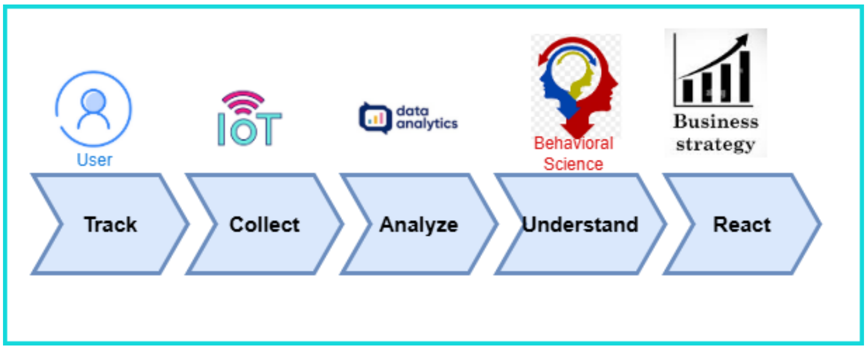

Figure 2: IoB Workflow

The figure 3 describes technical advancements of Internet of Behavior related with behavioural perspective in each advancement. Introduction of Internet of Things technology at primary level, the built system will have basic intelligence with semantic process design. Adding more intelligence in IoT, passive actors become self-organizing actors. The self organizing actors get the self learning behaviour due to intelligence. As the technology moves towards Internet of Behavior, the system becomes complex adaptive system which is dynamic system which is able to adapt and evolve with changing environment. The individual behaviour of actors influence activities of other actors in system. In this way, self-referential interaction loops develop in a specific networked setting. Such mechanism develops predictive analytics since behavior can be anticipated based on the history of individual action and received inputs from other actors driven by those actions. [6]

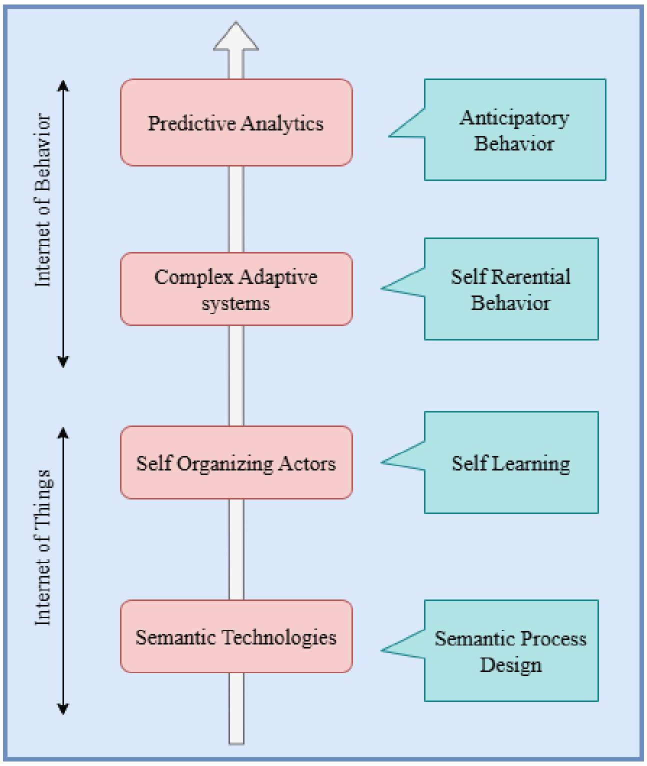

Figure 3: IoB with Design Intelligence

2.2 Engineering of Complex Adaptive Systems:

As described in figure 4, to design complex adaptive assistive healthcare systems, Adaptive Software Development Methodology can be used. Jesper Andersson, Luciano Baresi, Nelly Bencomo propose self-adaptive software life cycle which consists of two phases as offline adaptation and online adaptation. The offline adaptation is similar to traditional software development life cycle. In contrast, the online adaptation involves two key processes: evolution and adaptation, which work together to modify and continuously enhance the core application logic in real-time. [7].

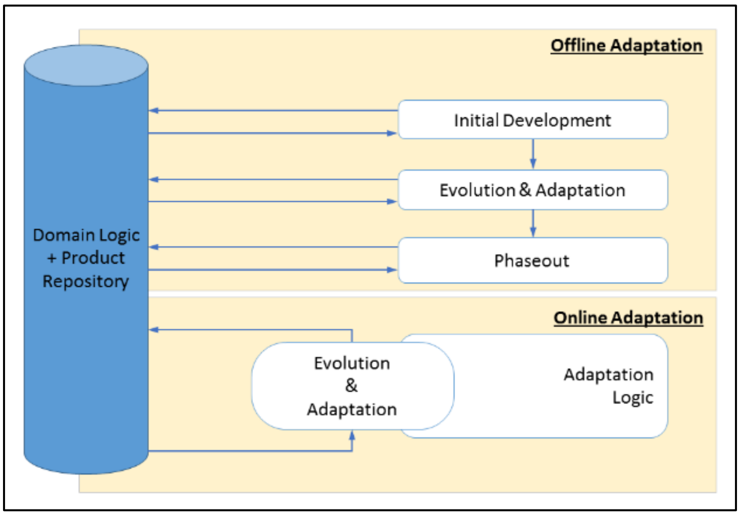

Figure 4: Adaptive Software Development Methodology

The autonomous systems which adapt their behavior or architecture at run-time have the capability of self-healing, self-protection, self-optimization and self-configuration according to runtime requirements [8]. These systems are well-suited for intelligent applications that are ubiquitous and user centric. To cope up with adaptations in requirements or the environment, the system analysis phase is executed continuously alongside the software, allowing runtime adaptation. As shown in figure 5, If the designer predefines the adaptation mechanism, it is called static adaptation, where the software selects an appropriate mechanism at runtime from the available options. On the other hand, if the system itself generates adaptation strategies during runtime, it is known as dynamic adaptation.

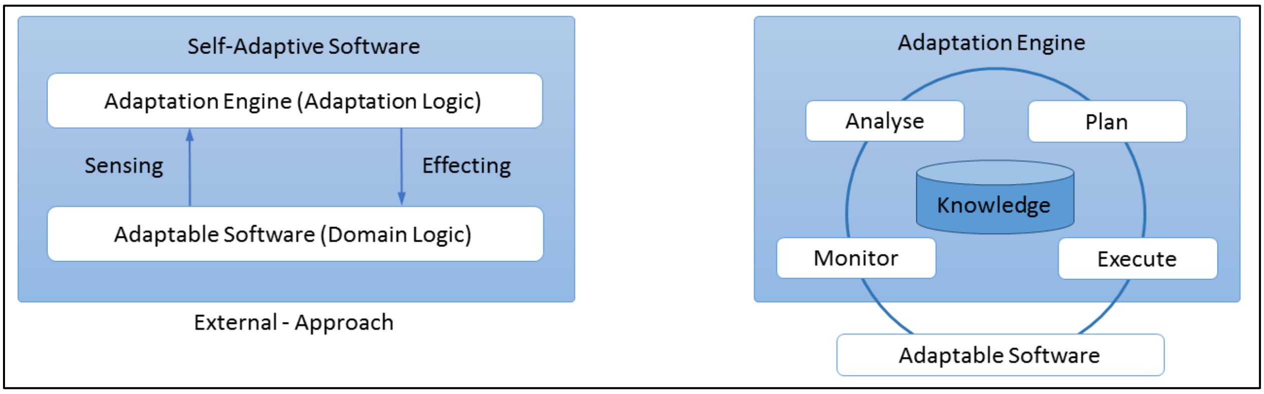

Figure 5. Two approaches of self-adaptive software with MAPE-k Cycle

2.3 IoB Conceptual Model:

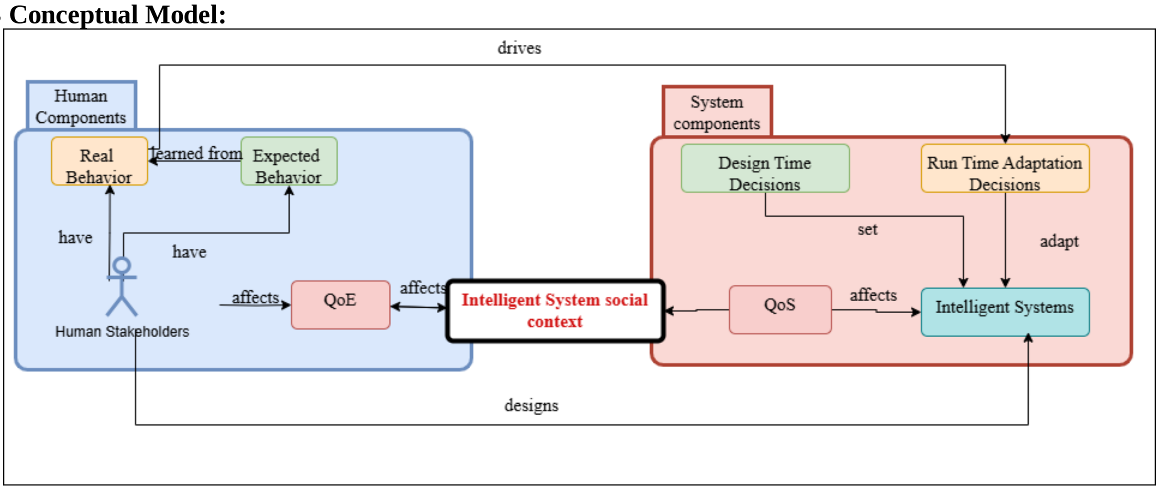

Figure 6: IoB Conceptual Model

The IoB conceptual model depicts human components, system components and their interactions required for software design and adaptation of new requirements.

1. Human Components:

a. Human Stakeholders: The stakeholders of system can be users, clients, developers, visitors who are direct or indirect users of system. The stakeholders are involved with their respective *characteristics*, *behaviors*, and *goals and intentions*.

b. Expected and Real Behaviors: Human behavior is driven by their goals and purposes.. IoB approach deals with behaviour of stakeholders and impact of behaviour on system. Expected behaviors are the actions that developers assume users will perform or that the system forecasts users will take. Real behavior, on the other hand, is what occurs during run-time and may deviate from these expectations. Therefore, based on the observed behavior, the system must implement different types of adaptations. Self-adaptive systems offer an effective solution for adjusting to both the expected and real behavior of stakeholders.

c. Quality of Experience: Quality of Experience (QoE) focuses on ensuring that users have a satisfying and effective interaction with a system, whether directly or indirectly. This involves developing methods to measure or understand user preferences and choices in various contexts. If QoE is not prioritized in design, the system may fail to effectively meet user needs and expectations.

2. System Components:

a. Intelligent connected systems: An intelligent system is designed with both functional and non-functional requirements. These define what the system should do and the quality it must maintain under different conditions, ensuring reliable and efficient operation. The intelligent systems adapt themselves as per new behaviors identified.

b. Quality of Service: QoS involves quality factors that could be measured, and used to define, design, and adapt systems. The QoS are specified by stakeholders. The main quality requirements IoB should assure are performance, energy efficiency, usability, resiliency, ease of use, interoperability, dependability, and efficiency etc.

c. Design-time decisions and run-time adaptation decisions: To deal with design time decisions, standard development practices can be implemented. Various architectural models linked to behavior and context should be designed to support run-time adaptation decisions. The resulting behaviors and architectures form patterns that serve as inputs to the knowledge base of run-time systems. *T*he run-time adaptation can follow a feedback control loop as shown in figure 5. To deal with run-time adaptation, framework like Continuous Adaptive Requirements Engineering (CARE) framework where runtime requirements become reflective requirements which are analyzed by the system itself at runtime can be useful.

3. Human-System Links:

The human-system interrelations depend on behaviour of people and behavior of people depend on context. The context can be physical context - the actual environment, such as geographic location, temporal context – time related information, social context - direct or indirect interaction of people with each other, with the system, or with objects located in the physical or virtual environment, computational context- computing resources, historical context - historical data,

The proposed research design applies IoB conceptual model with Adaptive Software Development Methodology to assistive healthcare application adaptive with current requirements, trends and latest medical patterns.

2. RESEARCH DESIGN

As shown in figure 7, the research design integrates IoB conceptual model with Assistive Healthcare System to make it adaptive considering various factors of Internet of Behvaior. The human stakeholders in this model are physician and patient/care taker. Their expected and real behaviors are shown in figure 8 and 9. The system components for design time and run time adaptation decisions are driven by behaviros of human stakeholders.

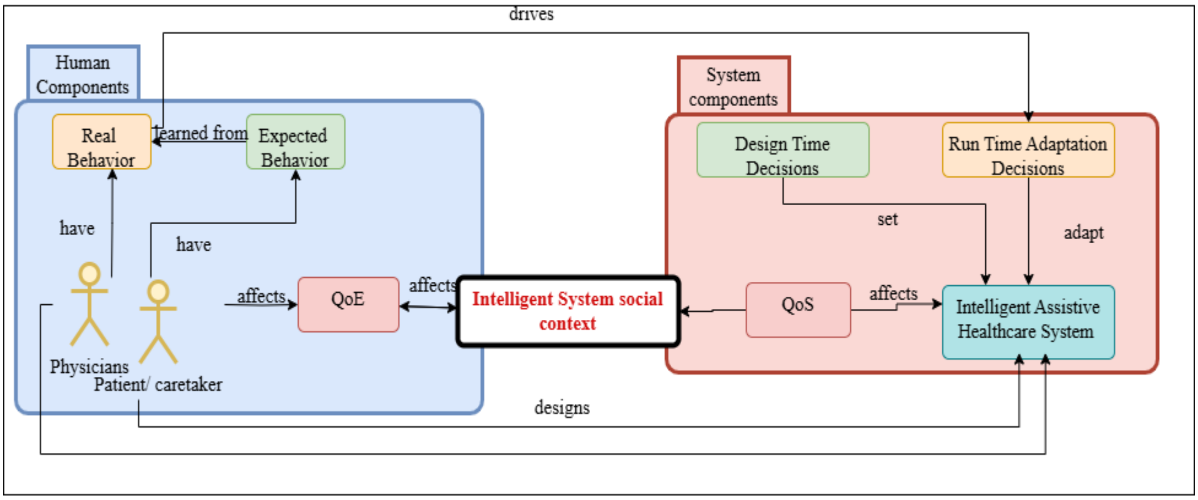

Figure 7: IoB Conceptual Model with Assistive Healthcare System

Figure 8 describes human components part in detail with IoB model for Assistive adaptive healthcare system. As the notation describe physicians and patient/caretaker are human stakeholders and their expected behaviour is described with action notation (capsule). Design time decisions are described by cloud notation and real behaviour where runtime adaptation is required is shown by slanted rectangle notation. Monitor physiological data, analyze and correlate data and observe, correlate and predict are the expected behaviors of physicians human component.

Run time requirements are handled at runtime by autonomous software. Runtime requirements are adapted by software with four types of adaptation.

Type 1 Adaptation:

These changes in requirements specification are anticipated at design-time only. The candidate solutions already exist in the knowledge base.

Type 2 Adaptation:

These types of requirements are based on new requirements like context, preferences, resources etc. The autonomous software monitors changes, evaluate changes and adapt the solution which is feasible alternate solution in knowledge base.

Type 3 Adaptation:

These types of requirements are most difficult to handle because new requirements identified are unanticipated by the designer. In this case, new scenario identified is analyzed in detail and specifications and solutions are added at runtime into case base.

Type 4 Adaptation:

This adaptation considers type 3 requirements for which no case-action is added or refined. This is the worst case scenario where new services are added in requirements database by research. This adaptation may take time to explore solution for new scenario. [9][10]

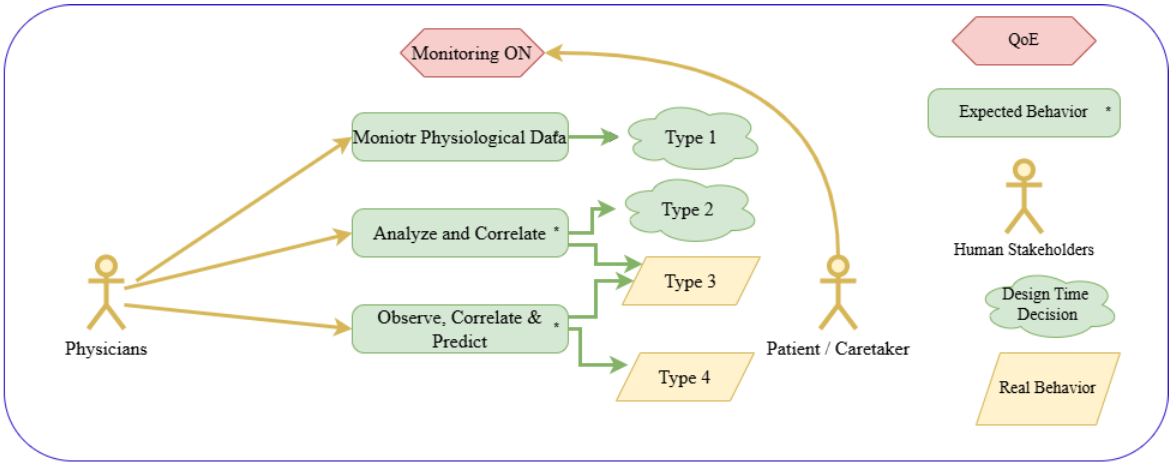

Figure 8: Human Components Part in detail with IoB model for Assistive adaptive healthcare system

Figure 9 describes system components part in detail with IoB model for Assistive adaptive healthcare system. As figure shows monitor agent, analyser agent, planner agent and executor agent are parts of Intelligent Healthcare Assistive System which take care of runtime adaptations of real behaviors of human components- physicians and patient/caretaker. The knowledge base supports analyser agent, planner agent and executor agent for type 3 and type 4 adaptations.

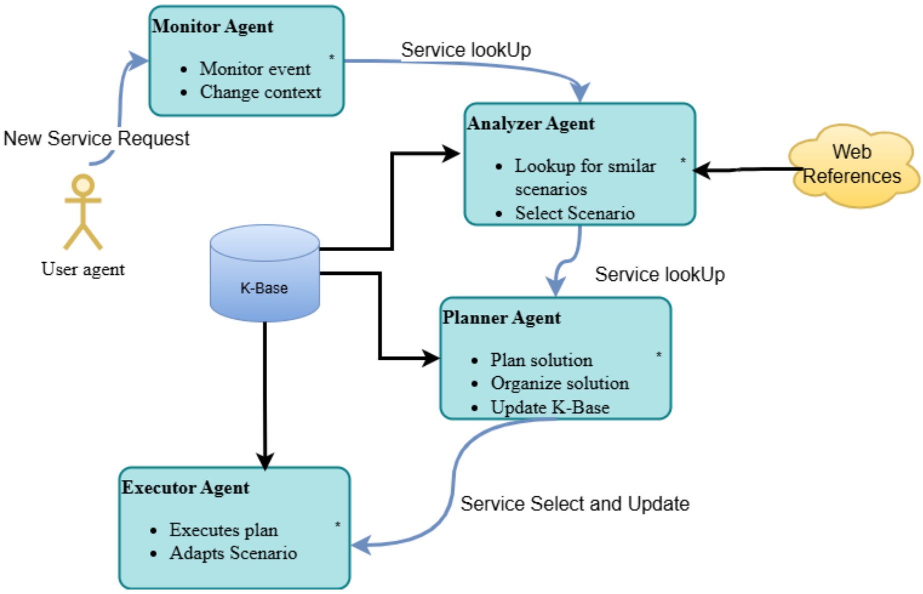

Figure 9: System Components Part in detail with IoB model for Assistive adaptive healthcare system

Thus, figure 8 and figure 9 describe the expected behavior of human components and system components. All the behaviors are linked to complete the task/ function. The above models show that human agents initiate particular tasks as expected behaviour and related agents of system components complete the same tasks as design time or runtime adaptation decisions. The effectiveness of this system can be checked by Technology Acceptance Model. (TAM). Technology Acceptance Model (TAM) can be applied on Assistive adaptive healthcare system with two factors: perceived usefulness and perceived ease of use. Both the factors depend on behaviour of human components and their intentions to adopt the system. Efficient communication, robust networks, and modern healthcare services can improve the effectiveness the system.

3. CONCLUSION

This paper presented a workflow for Internet of Behavior and how IoB can bring intelligence in system at design level. To bring intelligence in this system, it is necessary to have self-adaptive nature in the software. Hence, Self-adaptive Software Development Life Cycle is studied with MAPE-K cycle. The study is applied to Assistive adaptive healthcare system as an example. IoB conceptual model is studied and applied to Assistive adaptive healthcare system identifying human components, system components and their expected and real behaviors. The behaviors are mapped with level of adaptations such as Type 1, Type 2, Type 3 and Type 4. The System component part of the proposed framework describes various components of Continuous Adaptive Requirements Engineering (CARE) framework which facilitates adaptation in proposed system. The effectiveness of proposed system is assessed with Technology Acceptance Model. (TAM) briefly. As the future work, the effectiveness of the system can be assessed in details with the perspective of bahaviors of users. Also, the ontologies of expected behaviour and real behaviour can be created based on requirements identified during requirements engineering. These ontologies can help to create the knowledge base for particular system.

REFERENCES

[1] Mahyar T. Moghaddam, Henry Muccini, Julie Dugdale, Mikkel Baun Kjærgaard, "Designing Internet of Behaviors Systems", ICSA 2022 proceedings: International Conference on Software Architecture

[2] Mohd Javaid, Abid Haleem, Ravi Pratap Singh, Shahbaz Khan, Rajiv Suman, "An extensive study on Internet of Behavior (IoB) enabled Healthcare-Systems: Features, facilitators, and challenges", BenchCouncil Transactions on Benchmarks, Standards and Evaluations 2 (2022) 100085

[3] Dr. Rasika Mallya, "REQUIREMENT ENGINEERING FOR IOT PARTICIPATORY APPLICATIONS", SHODH SARITA, Vol. 7, Issue 25, January to March 2020, Page Nos. 280-286, AN INTERNATIONAL BILINGUAL PEER REVIEWED REFEREED RESEARCH JOURNAL

[4] Saumya Misra, Rachana Adtani, Yuvraj Singh, Simran Singh, Devanshu Thakkar, "

[5] Exploring the factors affecting behavioral intention to adopt wearable devices", Clinical Epidemiology and Global Health 24 (2023) 101428

[6] Haya Elayan, Moayad Aloqaily, Senior Member, IEEE, Fakhri Karray, Fellow, IEEE, Mohsen Guizani, Fellow, IEEE, "Internet of Behavior (IoB) and Explainable AI Systems for Influencing IoT Behavior"

[7] Franz Barachini , Christian Stary, "From Digital Twins to Digital Selves and Beyond Engineering and Social Models for a Trans-humanist World", Springer, ISBN 978-3-030-96411-5 ISBN 978-3-030-96412-2 (eBook), https://doi.org/10.1007/978-3-030-96412-2

[8] Jesper Andersson, Luciano Baresi, Nelly Bencomo, Rog_erio de Lemos, Alessandra Gorla, Paola Inverardi and Thomas Vogel, "Software Engineering Processes for Self-adaptive Systems".

[9] Rasika Mallya, Snehalata Kothari, "*Self-Adaptive Woman Health Monitoring System using MAPE Components"***,** ACM J. Comput. Cult. Herit., Vol. 10, No. 20, Article 25. Publication date: Month 2017.

[10] Nauman Ahmed Qureshi, ―Requirements Engineering For Self-Adaptive Software: Bridging The Gap Between Design-Time And Run-Time‖, PhD Dissertation, International Doctorate School in Information & Communication Technologies DISI - University of Trento, November 2011.

[11] Daniel M. Berry, Betty H.C. Cheng, Ji Zhang, ―The Four Levels of Requirements Engineering for and in Dynamic Adaptive Systems‖, DEAS '05 Saint Louis, MO, USA c 2005.