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Exploring the Biological Metaphor in Evolving Complex Cyber – Physical Systems

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Abstract **- "Expecting the Unexpected" is a vital facet of "Systems Thinking" that facilitates structural, not event-level solutions amidst conflicting demands and daunting constraints. Systems enable the understanding of how strategies work and why. In challenging times, it is crucial to remember, and practice the unique strengths of systems thinking and organizational learning. Today computational paradigms and metaphors have permeated virtually every walk of human endeavour.**

A method to expect the unexpected in a systemic manner is "Human-in-the-loop [HITL]". HITL is a branch of artificial intelligence that leverages both human and machine intelligence to create machine learning models. People are involved to validate a machine learning model's predictions as right or wrong at the time of training.

The use of biometrics has been successfully applied to security applications for some time. Biometric technologies are predominantly used to authenticate individuals in applications such as access control to specified resources, image processing and marking routine attendance. Biometrics attempts to automate the recognition of behavioural and physiological characteristics of an individual. Individuals provide certain personal characteristics to the sensors. The Human-Biometric Sensor Interaction [HBSI] is a conceptual model to study several concerns in usability related matters.

"Behavioural Biometrics" and "Morphological Biometrics" further advances in this type of applications. "Behavioural Biometrics" is related to the measure of unique and measurable patterns in human activities. It is more aligned to the social facet of the human being. "Morphological Biometrics" study the biological facets of human beings.

"Humanistic Intelligence [HI]" arises because of a human being in the feedback loop of a complex system, where the human and computer are inextricably intertwined. Wearable Computing Technologies and a wide range of implants have the potential to match the biological brain.

This paper is a study of the biological metaphor of evolving complex Cyber – Physical Systems.

1. Introduction

The century of complexity has begun. The evolving complexity that is interdisciplinary and has potential for both paradox and non-linearity banks on "Systems – Theory and Practice" to get to the other side. There are three dominant types of systems across the organizations. They are repetitive, adaptive and innovative systems. These systems determine the way the workforce gets aligned and learns.

Systems thinking represents a way of solving complex problems that fall outside well established disciplines. The challenges ahead include working with:

- Geographic Metaphor
- Computational Metaphor
- Biological Metaphor
- Epistemological Metaphor
- Anthropological Metaphor
- Sociological Metaphor
- System of Systems Metaphor

There are a few transformational theories spanning across several metaphors indicated above. The quest for General Systems Theory, Cybernetics and Adaptive Control Systems has

produced many ideas and eminent researchers with pioneering achievements.

Some of the areas in which systems thinking has proven its value include:

- Complex problems that involve helping many stakeholders see the “big picture” and not just their part of it
- Problems where dependence on past actions of others dominates
- Problems where the context has several interacting sub-systems that are heterogeneous
- Problems whose solutions are not obvious when studied in isolation

Human being is considered on the basis of two different dimensions of existence namely the biological and the social. Human beings happened on earth as a result of a long process of development. It is established that as biological organisms, they still retain a close genetic connection with the animal world. Man's organism has many features in common with the higher animals. Human beings are the pinnacle of a great biological system, the latest to emerge on historic timeline of evolution, and the most complex of all known organisms. Human being is an integration the biological i.e. the organismic and the personal i.e. the natural and the social, the inherited and what is acquired during a lifetime. Thus the biological factors should not be reduced to the genetic.

1.1 Biology

Well engineered control systems thrive on negative feedback. Biology on the contrary thrives of positive feedback. Thus any model based on biology is innately difficult to integrate with the prevalent feedback control systems. However, the biological metaphor involving Human-in-the-Loop holds the promise of steering to safety in quick time. Biology as a series of engineering problems with natural solutions appears to be a viable computational system using the biological metaphor. Please see the Figure 1 to draw an analogy.

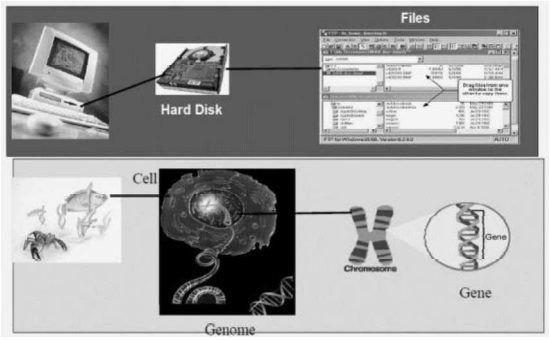

Figure 1. Operational similarity of a Computing System and Biological System

1.1.1 Biological Person

Any number of biological facts do not show the person as others perceive and think. This remains a core concern in using biometrics. It is widely known that any complex organism revealed by the usual observational methods of the biologists is distressingly incomplete. There is no observable or postulated biological property that automatically or by some logical necessity entails the rights of personhood.

Since at least the time of Aristotle, philosophers have debated what it is that constitutes an individual person or thing. What makes it a unity, numerically one? What distinguishes it from everything else?

An individual thing as a concept is clear and tends to be highly intuitive. An individual is something of a specific kind that is a unity having its own identity. In principle, it is always intuitively possible to discern it from any other individual even within the similar kind. Formal analysis of this principle poses a cluster of problems that are difficult to solve with the standard framework of

mathematical logic and the contexts of its effectiveness.

1.1.2 Individualism

Individualism is the first step towards the social human. It reflects the quality of being an individual i.e. individuality in possessing. It can also be an individual characteristic or even a quirk. Individualism is also associated with artistic interests and lifestyles where there is a tendency to make perceptible departures from the popular mass opinions and behaviours.

1.1.3 Individuation

Individuation is related to the metaphysical problems of constitution, composition, colocation, essentialism, and identity. The process of individuation is to become inwardly whole, discovering one's self beyond the ego states. It defines the essence of the human. Individuation entails the following concepts.

1. Symbols – imaginative, external and internal.
2. Consciousness and Paradoxes
3. Archetypes.
4. Complexes
5. Projections
6. Shadow
7. Anima [beauty, desire, mystery] & Animus [rationality, judgement, intellect]
8. The Metaphysical Human
9. Authenticity

"I have always said to my pupils: Learn as much as you can about symbolism; then forget it when you are analysing a dream."

Carl G. Jung

Human-in-the-Loop is thus a tough challenge in the evolving complex Cyber – Physical Systems from the standpoint of Biology. Individuation for the purposes of Cyber – Physical Systems may be another quest for a mathematical description of physical systems.

2. Biology and Physics

All physical processes are driven by the principles of physics. When these processes are applied to living systems, the realms of physics and biology merge to define how organisms function, from the simplest forms of life to the most complex. The internal mechanisms involve and invoke the widest possible spectrum of disciplines of science and mathematics.

"Measure what is measurable, and make measurable what is not."

Galileo Galilei

Even in the mid 20thcentury, most people thought proteins were the molecules of heredity. In just under 60 years, biology has been completely rewritten. The ability to read and write DNA has completely changed the face of biology. It has, in a sense, created a new domain of life. The science of physics has become an integral part in our understanding of this new domain.

The science of physics deals with the interrelationships between space, time, matter and energy. Biology of the 20th and 21st centuries deals with these same concepts on the molecular and cellular scale.

There are several principles of physics that relate to biology. Some such well established relationships are given below.

- Lattice and Nuclei
- Pattern Formation and Morphogenesis
- Flow and Spatial Patterning of Gene Expressions
- Magnetic Field Theory

In 1952, Alan Turing formulated a type of "Mathematical Biology" to model the chemical basis of morphogenesis. Theoretical Biology has produced useful results in making biology meet physics.

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Biological systems reach hierarchical complexity that has no comparison outside the realms of biology. However, the biological entities abide by certain fundamental physical laws the science of physics deals with the interrelationships between space, time, matter and energy. It is a challenge to specify a framework based on physics to understand the complexity of biological evolution. The complexity stems both from the evolving structures of the organisms and the rapidly increasing interactions between the cells.

Even in the mid 20th century, most people thought proteins were the molecules of heredity. In just under 60 years, biology has been completely rewritten. The ability to read and write DNA has completely changed the face of biology. It has, in a sense, created a new domain of life and living systems that evolve over a long span of time. The science of physics has become an integral part in our understanding of this new domain.

“Molecular and cellular biology have become more amenable to a research paradigm that melds experimental and theoretical investigations, and, more specifically, research that is geared toward an accurate description of how things move in space and time. It is, therefore, not surprising that physicists would be attracted to cell biological research.” - Charles Wolgemuth, Professor, University of Arizona, US

The cell is the “common denominator” in our understanding of life. The physics related to the motion of a single protein in a cell is very different (and much slower) than that protein’s motion in, for example, water. Many bacterial systems rely on dynamic “genetic circuits” to control critical processes. A major goal of systems biology is to understand these behaviours in terms of individual genes and their interactions. “Gene circuits” involve specific interactions between genes and proteins.

What are the principles of these genetic chemical circuits that operate inside cells? The real challenge is that unlike the static electric circuits designed based on known components, the genetic chemical circuits change rapidly. Also, the genetic chemical circuits are inherently noisy. Even noise can be used effectively to control the circuit. They are subject to stochastic variations with random fluctuations and non-deterministic behaviour. More importantly, some of the interactions may be truly irrelevant.

Rather than trying to “deconstruct” complex systems, scientists today are instead looking at a model for a simple gene circuit - a “bottom-up” approach to get a quantitative understanding of the principles of gene circuit design. This is known as Synthetic Biology.

Cellular clocks work as “feedback loops” where proteins are produced and then go out of the nucleus into the cell. It takes them time to re-enter the nucleus, where they are able to regulate (turn off) their own expression, causing the concentration of those proteins to gradually decline until they can no longer turn themselves off; then they begin a new cycle. The negative feedback in the control systems becomes evident in this aspect of biological systems. Also, at times the biological system s are not only stochastic but also deterministic. The cycle time is termed as “oscillation”. Certain oscillations can happen by design. A formal circuit theory in biological systems is elusive. If such a theory happens, one can possibly tune the biology of the brain or the heart much like a radio is tuned.

"We decided that [by] writing new biological software and creating new species, we could create new species to

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do what we want them to do, not what they evolved to do."

J. Craig Venter,

Lead for the first draft sequence of the human genome and assembler of the first team to transfect a cell with a synthetic chromosome.

"All great insights and discoveries are not only usually thought by several people at the same time, they must also be re-thought in that unique effort to truly say the same thing about the same thing."

Martin Heidegger, a German Philosopher

In biological terms, a human being, or human, is any member of the mammalian species Homo sapiens. However, human beings not only define themselves biologically and anatomically, but also in psychological, social, and spiritual terms.

3. Human – in – the – Loop [HITL] – The Biometric Approach

The HITL for Biometrics has evolved as shown in Figure 2.

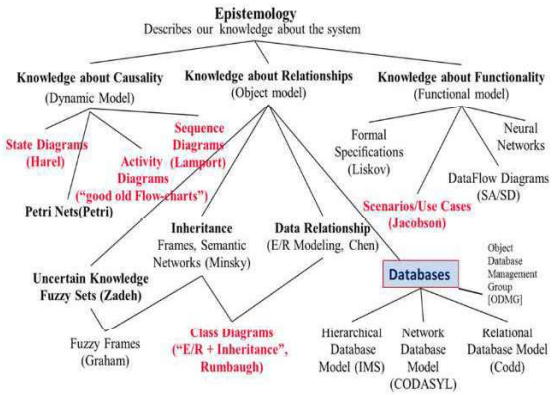

Figure 2. Evolution of HITL in the Biometric Approach

Structuralism and Objectification are the corner stones in this approach. The identity and diversity of individual objects may be grounded or ungrounded, and intrinsic or contextual.

Intrinsic individuation can be grounded in unique identification of the object or absolute discernibility. Contextual individuation can be grounded in relations, but this is compatible with absolute, relative or weak discernibility. Contextual individuation is compatible with the denial of unique identification, and this is more harmonious with science. Structuralism implies contextual individuation. In the context of mathematics all individuation is in general primitive. In physics contextual individuation may be grounded in relations with weak discernibility. In mathematics, an isomorphism is a structure-preserving mapping between two structures of the same type that can be reversed by an inverse mapping. Two different objects can be isomorphic i.e. have similar structures. It is not possible to identify objects in a structure except through the relations and functions that are defined on the structure in which the object has a place. In other words, only the objects permissible with the pre-specified relations and functions are deemed identifiable.

The Biometrics Technology was primarily used by the law enforcement. Presently, it is increasingly being used for verification of the Identity of a person. Biometrics is a method of recognizing or verifying a person's identity based on physical or behavioural characteristics. Every human being possesses certain unique features in terms of both physiological and behavioural characteristics that mark him / her as an individual. Anthropometry is the science of obtaining systematic measurements of the human body. It has been widely used for identification of individuals.

A Biometric Sensor is a device that converts the known biometric traits of any given individual into electronic signals. These devices are transducers

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that model the human trait for the design and development of electronic circuits to identify individuals. However, the biological signals are not the same as the electronic signals. Biological signals, or biosignals, are space, time, or space-time records of a biological event such as a beating heart or a contracting muscle. The electrical, chemical, and mechanical activity that occurs during this biological event often produces signals that can be measured and analysed. Cybernetics is the science of communication and control to synergize the distinctive signals in machines and living organisms.

Biocybernetics is an abstract science and is a fundamental part of theoretical biology. Biocybernetics is the application of cybernetics to biological science for neurology and multicellular systems. Biocybernetics plays a major role in systems biology, seeking to integrate different degrees of information to appreciate how biological systems perform. Biocybernetics can be used identification, communication and control of Individual organisms within a biological system. It has been extensively used in medical and healthcare systems.

Bioelectrical signals are generated from the complex self-regulatory system and can be measured through changes in electrical potential across a cell or an organ. Anatomical parts of body and signalling methods include face, fingerprint, hands, eyes, ears, veins and voice while behavioural characteristics include handwritten signature, keystroke and gait. The limitations using the traditional biometrics include that they are unique identifiers that are not confidential and secure to any given individual. Using bioelectrical signals as biometrics offers several advantages to an identity management system. Besides their uniqueness, the bioelectrical signals are confidential and secure to an individual.

4.The Impact of Biology on CPS

Software engineers need to be technocrats both as individuals and as team members through vision and ingenuity. The Software Industry is recognizing that a healthy employee work/family-life balance is essential for long-term enthusiasm and success. It is clear that a strong architectural plan with input from all stakeholders creates a vastly different, participative and delivery working environment. The continued commitment to creating excellence and an atmosphere that embraces change are foundational characteristics of the Software Industry in future.

Treating people like they're human beings instead of hours to extract value from is an old fashioned concept that's coming back into fashion. Software Engineers have the greatest degree of variance in the level of their productivity. In the past 10 years, the scale of relative "valuable-ness" of otherwise-similarly-skilled-employees has grown quite a bit wider. Also, it's cheaper to humanize and retain software professionals over a long term. Humanizing entails Safety and Security, Human Relationships and Personal Growth. This is proving to be an answer to the productivity paradox in Software Engineering.

This paper is a study on HITL for blending technocracy with humane practices.

5. The Matrix of Human Body - Healing Arts & Sacredness

Understanding the relationship between space, culture and belief is formative in the direct experience of seeking healing.

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This relationship within the ambit of spirituality in the context of interdisciplinary perspectives is an essential study in healing arts. The author opines that the significance of spirituality in the 'uncertain' quest for alleviation or cure is best comprehended in abstract spaces with very little or no material involvement. This is the traditional view of healing in India. The human body has not evolved further over the past 10,000 years. The author prefers the "Badarayana Brahma Sutras" by Sage Badarayana Vyasa to assure comprehensive healing from the highest abstraction of the human being.

There are two important concepts:

- Rachna Sharira [Anatomy - structure of Human Beings]

6. Kriya Sharira [Physiology - Mechanical, Physical, Bioelectrical, and Biochemical functions of Human Beings]

The author reckons the practice on the basis of timing. "30 Days or One Month is 1 Pitruja Day and Night" and "12 Months or 1 Year is 1 Daiva Day and Night". After 12 months or 1 Year healing happens only in the realms of spirituality.

7 Pitruja Days i.e one week is ample time for the process to become completely independent of the physical being [Kriya Sharira or Physiology] of both the healer and the healed. "Pitruja" is associated with the Fatherly.

"Rachna Sharira" requires another 23 / 33 days that are Matruja to assure the nourishment of the societal framework. Indic scriptures postulate Matruja days as motherly.

The modern medical practices of prescriptions and documentation serve the 40 days spell of time. The necessity to create sacred space in the examination rooms and patient interactions is also justified in this process.

A space can be sacred, providing those who inhabit a particular space with sense of transcendence - being connected to something greater than oneself. The author prefers sacred geometry to make this space analytical enough for studying the science in the healing traditions. The sacredness is inherent in this approach based on Sacred Geometry. It scales quickly even to the societal healing and facilitates the perception of holism in the process.

The core distinction in the Indic healing arts is that, the meta-physical sacredness seamlessly transcends into the beings as expounded in the "Badarayana Brahma Sutras". A matrix with the alphabet assuming the mother-forms is the necessary mapping for both quantitative and qualitative analysis.

7. Conclusions

The biological basis of "Intelligence" has provided the most abstract synergy for the Human-in-the-Loop. Also, the presumption that the basis for the bioelectrical signals is chemical began to be thankfully challenged. Further explorations on Intelligence and Cognition resulted in some noteworthy research. Confronting human intelligence with methods that have no plausible claim to mimic its cognitive processes have always had limited achievement. It is becoming increasingly clear that intelligence operates on a substrate that is not silicon.

Is biology the next natural choice for the substrate?

Genetic vulnerability during development of the human being and evolution that takes an erratic path to complexity have been tough challenges in choosing biology as the substrate.

Complex systems science considers systems with many components. These systems could be physical, biological, or

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social. This paper is an exploration on the possible impacts of biology in providing a working model for studying "Human-in-the-Loop" context of evolving complex systems. Human-in-the-Loop is important for assuring safety in the evolving complex system.

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Formal Methods for Enterprise Application Integration

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***Abstract*— In the past few years, there is an enormous growth in enterprise computing. Large enterprises have more than thousands of applications that work in tandem to support enterprise business processes. The enterprises typically adopt internet technologies. Enterprise Application Integration (EAI) provides the option to integrate the different applications to enhance the functionality and sharing of the information among different applications. Integration increases the automation of business process and significantly reduces the redundancy of data functionality and the IT infrastructure cost like maintenance, management and operational.**

Presently, the Formal Methods use mathematical models for verification and analysis of the Software life-cycle. In this paper, the focus is on the possible formal levels of Enterprise Application Integration and proposed a theoretical, computational and process oriented collaboration model for integrating formally. Explained different formal method technologies for EAI. This research will address and propose solutions of the different enterprise applications while integrating them in terms of mathematical formalism.

***Keywords*—Autonomous Robotic System, Complex and Control System, Enterprise Application Integration, Formal Methods, Formal specification, Formal Verification, Process Model, Petri Net, Z Specification Language.**

I. Introduction

The traditional meaning of enterprise is the company or organization for commercial purpose. In the IT world, the meaning of the enterprise is different and is often fuzzy [19]. The enterprise is an organization that follows some characteristics like size or location of the company, software, and hardware applications which are used for the enterprises, and management of the enterprise.

Integration is not a new methodology in the field of Information and Communication technology and has been used for the past 50 years. The early systems were designed and developed without concerns of change in technology and the requirements were estimated based on the context. Technologies such internet and e-commerce are mandating the integration of the internal systems to satisfy the customer's needs. The data and functionalities of different applications need to be shared. Hence, there is a need to integrate the applications even if they run on different platforms for different purposes. EAI is one of the emergent frameworks to facilitating the integration of different applications.

Formal methods are based on mathematical techniques and notations used for describing, analyzing and specification of properties in software systems. These mathematical techniques are based on predicate logic, set theory, relation, functions and graph theory [4]. Based on the model of software in the life cycle, we will get a result from requirement analysis in the form of informal language. The specification is the phase of transforming the informal to formal which satisfies the requirements. The phase from design to program corresponds to the development of the code. The verification and validation are the two basic principles in the development of the system. There are many tools and methods for verification and validation of the system. The formal verification, formal specification languages, fundamental concepts of model checking and theorem proving are discussed in this paper.

In this paper, Section 2 gives the details of EAI. Section 3 provides the different types of EAI, while Section 4 and Section 5 gives the fundamentals of the formal methods and their impact in software engineering. Details of Formal Methods and some industrial scenarios are discussed in Section 6 and Section 7. Section 8 explains the case study with one of the specification language. The proposed work of

research is discussed in section 9. Finally, concluded the paper in section10.

II. Enterprise Application Integration

Every Enterprise strives to improve the productivity, reduce cost and improve the efficiency business process. It is possible with the effective combination of Independent Systems, Data Exchange and Data Sharing between all processes of an enterprise. Enterprise Application Integration (EAI) is developed as a solution bridge the gap between business enterprises and IT sector to interact across different platforms.

Enterprise Application Integration (EAI) is the process of integrating the different applications that were developed by using different technologies on various platforms. There is a need for an architecture that provides for inclusion, interactivity, and context amongst all the stakeholders in the enterprise system.

One of the main challenges in the enterprise applications is interoperability [23]. There is a need to develop new methodology and framework for implementing the EAI. That implemented framework need to be the best fit for enterprise and it has to satisfy the requirement specification of the enterprise. New technologies like cloud computing and Internet of Things (IoT) are evolving in the market, so new integration methodologies are needed for such platforms.

The main aim of EAI in the enterprise is to ensure that all of its applications work together as though it is a single function. Model-driven development is a good methodology.

There are different criteria which must be considered when we integrate the applications. Reliability of target services, technology selections of different applications, extensibility, data format, data coupling and so on. For the question "Which integration approach best addresses which of these criteria?" there are different integration methods. Usually, no particular integration method which satisfies all the different criteria and constraints.

III. Types of EAI

There are different levels of EAI which depends on many factors including company size and budget, type of industry, integration and/or project complexity and so on.

The four well known levels of integration [17] are given below,

- Data Level
- Application Level
- Method Level
- User Interface Level

A. Data Level

It extracts data from one database to update another data base. Sometimes the extracted data may be transformed before updating the other database [3].

The best example of the data level is ETL (Extract, Transform, and Load) tool which can extract, transform and load data from different data sources and store in a common repository called as a data warehouse. Fig.1 represents the data level integration between the data sources.

Low cost and low risk are the main benefits of this level. Because, we are not modifying any code in the existing applications and no expenses to developing, testing and deploying new versions of the applications. The main drawback of this approach is to maintain the database design to understand the operations of the data generated by this approach.

Fig.1. Data-Level Integration

B. Application Level

This is the level of integration it consists of different interfaces which provided by the packaged applications to access the information between packages. Generally, this kind of integration is done as follows.

- Extracting the information from a source application through a provided application interface.
- Convert the data in the understandable format of the target application.

- Transfer the information to the targeted application.

"Message Broker" approach is the most common usage to implement this kind of integration [19]. In this approach, it controls the flow of information through hub and bus frameworks.

Fig.2 shows the application level integration. The interfacing between the different applications is relatively easy due to applications interfaces are provided by the applications. This is the main advantage of this level of integration. The disadvantage of this approach is the cost of the message broker.

Fig. 2. Application Level Integration

C. Method Level

Method-level integration is similar to application level interface but at a lower level of granularity. The main idea behind this level does not even share the functions but to share the different methods used in this function. Reusing approach is emphasized in this level of interface [29]. So, all other enterprise applications need to implement the same methods can use them without having to rewrite it. Fig.3 denotes the method level integration between different methods.

This integration level can be done with a lot of technologies like Java RMI, CORBA, and DCOM and so on. The emerging trend in implementing this approach is Web services [30]. The methods are shared easily by using web services.

The ability to reuse business logic and sharing the methods make this approach very suited for EAI. This method supposes the modification of existing applications to allow the sharing at such a low level.

Fig.3. Method Level Integration

D. User Interface Level

It is used for bundling applications into one by using their user interfaces as a common point of integration. It consists of replacing existing user interfaces of legacy systems and the Windows, Icons, Menus, and Pointer based interfaces of recent applications with standardized interfaces. User interface level integration is less expensive and less flexible than other approaches. The code of the existing applications is not modified [7]. The given below fig.4 represents the user interface level integration between two legacy systems.

Fig.4. User Interface Level Integration

In this paper, three more levels in enterprise application integration are proposed. They are,

- Architecture Level
- System Level
- Formal level

E. Architecture Level

Every component of the enterprise uses different data formats, various programming languages, and even different operating systems with a standard interface. Service Oriented Architecture (SOA) [6] is the best model to integrate the various components at the architecture level.

It integrates different services from different vendors, independent platforms, and different technologies [15]. The main advantages of this level integration are Loose Coupling, High scalability, and flexibility. It enables interoperability across heterogeneous systems.

F. System Level

System level integration is the process of combining different systems and software to behave like one physical and functional system. The system level integration is more important in the modern internet world. Many systems and applications are interconnected to different systems and sometimes it needs to connect already deployed systems. Fig.5 shows the system level integration.

ESB (Enterprise Service Bus) approach is the type of integration approach in which all subsystems will be communicated to other subsystems. The main benefits of this level integration are,

- More efficiency
- More profitability

Fig. 5. System Level Integration

All levels of EAI including the proposed levels are shown in the figure 6.

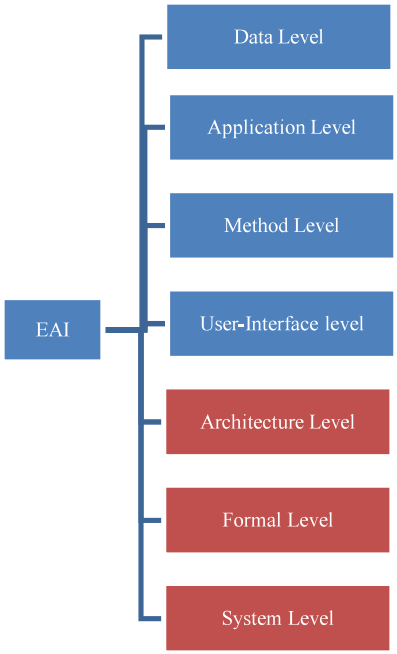

Fig. 6. Total level of EAI

Formal level of enterprise application integration will be discussed in the next section. There is a lot of research going on in the Enterprise Application Integration [EAI]. EAI is a very complex integration mechanism because of its distributed nature. Moreover, the development process and requirements of applications change rapidly. A new methodology and framework are needed to develop and achieve the meaningful EAI to integrate even the applications built for cloud computing and IoT.

Data security and privacy is another challenge in the EAI. Presently, there are not many comprehensive efforts in maintaining data security and privacy. EAI is not a simply integrating the applications built on different platforms. It is also to facilitate cooperation between different processes and business customers. The core challenges in EAI are as follows. EAI today demands the ability to integrate millions of sensors and computers, big data analytics to wireless networks. There is a need for theories and formal proofs to verify the design and development of EAI.

IV. Formal Methods

Formal methods can be present in all phases of a software project. The Project manager will decide when these methods should be used in different phases to detect more defects. Most of the time we can ensure that to get defect free software. Usually, software systems almost always contain some errors, even after rigorous testing in development and user acceptance. Some surveys saying that minimum 3 to 20 errors may occur from every thousand lines of code at the time of software putting into service and after finishing the normal testing and user acceptance testing[13]. When the developer has used formal methods, even in part of development, it becomes easy to identify the defects easily, quickly and thoroughly than the traditional methods.

Formal methods are categorized into two categories model–oriented and property–oriented approaches [31]. In a model-oriented approach, the system's behaviour is defined by creating a model of the system in terms of mathematical structures like tuples, functions, sets, sequences, relations and so on. But, in property-oriented approach, the behaviour of the system is indirectly defined by expressing its properties in the form of a set of axioms which satisfies the system. The Examples of popular model-oriented specification techniques are Z [28], CSP, and CCS and so on. Model-oriented

approaches will use in future software life cycle process also because changes of some specification will effect on the entire specification of the system. Property-oriented approaches are suitable for requirements specification because they can be easily changed. They specify a system as a conjunction of axioms and you can easily replace one axiom with another one.

V. Impact of the Formal Methods on Software Systems

Reliability is one of the major challenges in the software and sometimes it is very critical for the people. When a failure occurs, it leads to disasters where people die or large sums of money are lost. Such software is very complex and it is not easy to verify the correctness. It is often full of bugs and results in delay, over cost and many usability problems. The best and famous example is the Ariane 5 rocket explosion in 1996 that was due to a software bug (a data conversion of a too large number). To overcome such problems, it has been suggested to use formal methods in software, especially in the safety critical system [5, 14].

Formal methods help us to discover the errors in the early stage of the life cycle in the software development process. It reduces the overall cost of the project. Formal methods will provide the kind of evidence and give the solid reason for trust in the product. It is needed in heavy industries like avionics, telecommunications, and automobiles and so on where half of the projects fail. Formal methods for end-to-end flow control in EAI are necessary.

The benefits of formal methods include a decrease in the rework process, automatic verification of some properties and most importantly finding errors in early stages. Formal Methods can also be used in reverse engineering for the model and analyze existing systems. Formal methods do not give any guarantee to the correctness of the system but can be used to increase the level of correctness.

The primary reason for failures in software engineering is unstable requirements and specifications [11, 31]. The formal methods use mathematics to structure and analyze the requirements and specifications in a manner where changes can be systematic. Formal methods help the engineers to construct more reliable systems.

VI. Basics of Formal Methods

A. Formal Specification

A specification is said to be formal if it is expressed as a notation or formal specification language in which the notations are based on mathematical logic and set theory. The formal specifications are used in the analysis and design phases to record the requirements and design decisions in the development lifecycle [10].

It can be used to predict the behaviour of the product before implementation by using some formal analysis and test cases.

The formal specification is characterized as being abstract and a refinement of requirements analysis phase of the development lifecycle. A specification is created in the requirement analysis phase and it should describe the requirements of the software system to be implemented. The mathematical notation must prove the properties the formal specifications in order to verify and validate them.

Verification is only concerned with the correctness of a product with respect to its specification [18]. Another question is whether the specification correctly describes the problem to be solved. Validation is the act of investigating the latter. Specifications properties can be validated formally by using some mathematical statements. It can also be validated by testing when the specifications are executable form.

B. Formal Specification Languages

A specification language is a formal language which is used in the requirement analysis phase and design phase of the software design lifecycle to describe the system. Many specification languages exist that are suited for different kind of systems and different contexts. Each formal language has its own mathematical framework. It consists of notations of models and notation of statements that can be used to express the

properties of models that must be satisfied by the statements.

A specification can be a syntactic presentation of a model in which case it is said to be model-oriented specification language. This model is created using well understood mathematical entities such as functions and sets. Ex: B [26], VDM [22], Z [28] and so on.

A specification can be a syntactic presentation of a collection of statements or properties in which case it said to be property oriented specification language. This language is constructed using logical axioms, operations and their relationships and temporal logics. Example: CASL, Maude, and cafeOBJ and so on. For specification of concurrent systems, there is a famous language called CSP and CCS, it is constructed using process algebra.

C. Formal verification

Verification is the act of investigating whether the product is correct i.e. satisfies its specification. When mathematics is used for verification process it is called as formal verification. During the verification of the system design, a large number of theorems are proved. All these proofs are informal (not in mathematical form) and keeping track of the details of the proofs and interrelationship among the various theorems can be overwhelming. To ensure high safety, security and reliability proofs must be carried out with a high degree of precision. When the formal specification is used in the design and requirement phases, it is possible to use formal verification technique. Formal verification uses mathematical logic [33].

The advantage of formal verification is considerable in any context to find the defects before the system is implemented. The major approaches of formal verifications are theorem proving and model checking.

1) Theorem Proving

It is mathematical logic and proof for a statement to be true. The statement is known to be true and is said to be theorem when the act results in a proof. If a proof is not found, one cannot conclude that the statement is false.

There are many ways to prove that implementation satisfies the specifications. The proof can be either manual or automated. It is not suitable for large software and hardware systems. Proofs can also be interactively checked by the machine based on the steps provided by the human. They can give a guarantee of correctness if the theorem prover is correct. Automated theorem prover can solve the problem within a reasonable time. It is faster than interactive proving. Many problems cannot be solved automatically [10].

This approach needs large manpower to prove small theorems. It is difficult to prove large and hard theorems. It is usable only by the experts. It requires a deep understanding of both system design and methodology. There exist many programming tools which construct formal proofs [4] some of them are given below.

Based on the proof checker Meta Math and Mizar so on are the programming tools in that it can check automatically whether the suggested proof is actually a correct proof of the given theorem.

Based on the interactive theorem prover PVS, Isabella, HOL, ACL, and COQ so on are the tools that construct a correct proof by interactively. This is a most common form of tools.

Based on the automated theorem prover SPASS and Prover 9 so on are the programming tool that automatically searches for a proof of the given theorem. These tools are most difficult to create as it is and computationally hard to find a proof.

2) Model Checking

Model checking is the automated approach to verify that a model of a system satisfies a formal specification of requirements to the system. In this approach, the models describe how the state of the system may evolve over time. Tools that automatically perform model checking are called model checkers.

The process of the model checker is to create a model of the system as a first step and to formalize the requirement by obtaining a formal specification of the system. The model checker returns information about whether the model satisfied the property of the specification. Model

checking is a promising technique for the improvement of software quality. A model of a program consists of states and transitions, and a specification or property is a logical formula.

A model checker is a tool which automatically performs the model checking. Many of model checkers exist. Each model checker has a different specification language for expressing the model and expressing the properties [20] some notable examples of model checker are SPIN, NUSMV, and SAL.

Here we can compare the model checking and theorem proving, Model checking is fully automated and much easier and faster to use than the theorem proving. Model checking can't be used for generalization of generic parameter system.

VII. Impact of Formal Methods

A. Impact of the Formal Methods on Avionics

Formal Methods are being incorporated in the aircraft and spacecraft software design and verification process [27] Pete Manolios, USA, focuses on integrated modular avionics, verification cost, and system integration. Marc Pantel, FRANCE, focuses on developing embedded systems in avionics and safety requirements. Guillaume Brat, NASA, USA, focuses on sound, precise and scalable static analyses of flight control system [9].

There are two important methods for verifying the avionics formally. Deductive Method and Abstract interpretation based static analysis. The first deductive methods are based on a hoare logic concept with tools of Caveat and Frama-C. The second technique is based on abstract interpretation with automated tools like Astree, aiT, Stackanalyzer, and Fluctuat.

B. Impact of formal methods on Automobile

The automobile industry is rapidly changing from a mechanical industry to one driven by innovation in electronics and embedded software. Many new safety and convenience features are being designed in the presence of traffic and whether condition, driving skills level, road condition, formal methods are needed.

C. Impact of formal methods on Virus-malware

Researchers in academia and industries are beginning to develop anti-virus technologies founded on formal methods of analyzing programs. These methods with mathematical foundations have mostly been developed for optimizing compilers and more recently for hardware and software verification.

Some formal models [43] of virus transformation are developed and tested the against virus attacks. Proposed [44] some nonlinear mathematical models to study the role of antivirus program in the computer network and analysed. Present malware detection tools are operated by searching for pattern matches with respect to signatures of known malware. These detectors generally in capable of identifying newly released malware. We need a formal method to investigate the malware detection and behaviour.

D. Impact of Formal Methods on Telecommunication

Telecommunication services are defined as a service that is provided by the public switched telephone network. The main system requirements of telecommunication services are to communicate between user and devices and interaction between two communication systems with one another.

Some characteristics of telecommunication services are [8] concurrency, distribution, relativity, code size, complexity, large-scale environment, reliability, availability, and interoperability so on. The telecommunications industry has developed many standards for fulfilling the requirements and characteristics [2].

Mostly SDL (Specification Description Language), Z and PROMELA [42] are used in the telecommunication industry.

E. Impact of formal methods on Defense

The use of Formal Methods is mandatory for certain classes of military software. The major problems are the integration of different components and subsystems, such as radar, electronic support measures, navigation, communication and mission data processing.

Colored Petri Nets [40] [41] are one of the formal specification language and graphical oriented modelling language for the design, specification, and verification of distributed systems. One of the key technical challenges of defense is to develop high assurance safety critical cyber system.

F. Impact of formal methods on Robotics

An autonomous system is an artificially intelligent entity which is interacting and make a decision by means of inputs and the robotic system is a physical entity that interacts directly with the physical world. So we consider Autonomous Robotic System as a machine that uses Artificial Intelligence (AI) technology and physically interacts in and out with the real world. Autonomous Robotics is a very complex, hybrid system and combination of both hardware and software. Nowadays, Autonomous Robotics is being used tremendously in many fields like Driverless cars, Pilotless Aircrafts, Industries and acts as Assistants In many domestic and international organizations.

The common challenges of autonomous robotics systems are heavily dependent on software control, exact decision making, and deployment in critical scenarios, along with it requires strong verification methods to deal with all mentioned challenges. Here the concept of Formal Methods is needed which is a mathematical-based technique, for both verification and specification of systems, to ensure the correctness and evidence for the robotic systems.

Most of the formalisms used to verify or specify the robotic systems. We can divide the formalisms like set-based, automata, logics, process algebras, etc. Set-based formalism like the Z and B-method are representing a system using set theory logics and capturing the manipulation of data. [35] Describe a formal reference model of a self-adaptive system called FORMS by using Z specification language. [36] Proposed a Jaza animator by using Z specification language and java debugger to check the run time monitoring system. This is used as a model for a robot assembly system in the NASA ANTS project [45].

Petri Net and Finite state automata are the formalisms to specify the behaviors of the system. [40] In that they mentioned the Petri Net logic to capture the robot plans. The Petri Net models are used to analyze the deadlock and resource usage of robots.

Temporal logics formalisms are the most relevant formalisms for autonomous robotic systems to analyze and verify the systems. [37] Proposed some rules and assumptions by using Linear-time Temporal Logic (LTL) to verify the autonomous pilotless aircraft. [38] Represent the model by using the Probabilistic Temporal Logic (PTL) for safety rules and the environment of the autonomous robot assistants. These verification and specification results improve the confidence in the safety of the robot's high-level decision-making.

VIII. Case Study

In this section, we present a case study with two applications. First application had explained the details of the faculty name and their contact number. The second application includes the address of the faculty with some authentication procedure.

The objective of the first application (Michael Butler 2001) is to construct the telephone directory system in the university to maintain the faculty names and their contact numbers. The specifications or requirements are like,

– A faculty may have one or more telephone numbers

– Must be able to add new faculty and/or new entries

– Must be able to remove faculty and/or existing entries

– Must be able to query the system for a faculty or number

The system behaviour is implemented by Z [32] [28] schemas. The schemas are described as abstract specifications and it is also implemented as concrete designs with added details to provide sufficient confidence about

the specification before the coding. Our Z schema must satisfy the above mentioned requirements.

The below schema represents the creating the *PhoneDir* for storing the faculty name and contact number.

_PhoneDir

faculty:ℙ *person*
directory: *person*↔*phone*

dom *directory* ⊆*faculty*

_Phonedir′

Faculty′:ℙ *person*
Directory′:*person*↔*phone*

Dom directory′⊆*faculty′*

_ΔPhoneDir

Faculty,faculty′:ℙ *person*
Directory,directory′:*person*↔*phone*

dom directory⊆*faculty*
dom directory⊆*faculty′*

_ΞPhoneDir

ΔPhoneDir

Faculry′=faculty
Directory′=directory

The schema *Addmember* represents the adding of faculty name in the directory. It will check whether the faculty already existed in the directory or not. If it does not exist it will be added to the faculty data and it will modify the faculty and directory automatically. The next schema *Facultyexists* will execute if faculty already existed.

_Addmember

Δ*phonedir*
name?:*person*
rep!:*MESSAGE*

name?∉*faculty*
faculty′=faculty∪{*name*?}
directory”=directory
rep! = *“Ok”*

_Facultyexists

Δ*phonedir*
name?:*person*
rep!:*MESSAGE*

name?∈*faculty*
rep!=”*Faculty already exists”*

The below schema *AddEntry* represents the adding the entry of the faculty name and phone number into the directory.

_AddEntry

$\Delta phoneDir$
name?:*person*
number?:*phone*
rep!:*MESSAGE*

---

name?$\in$*faculty*
name?$\mapsto$*number*?$\notin$*directory*
directory′=*directory* $\cup${*name*?$\mapsto$*number*?}
faculty′=*faculty*
rep!= *"Ok"*

Removing the faculty and removing the total entry were represents in the below schema.

_Removefaculty

$\Delta phoneDir$
Name?:*person*
rep!:*MESSAGE*

---

name?$\in$*faculty*
faculty′$\in$*faculty*\{*name*?}
directory′={*name*?}$\lhd$*directory*
rep!= *"Ok"*

_RemoveEntry

$\Delta phoneDir$
Number?:*phone*
Name?:*person*
rep!:*MESSAGE*

---

name?$\mapsto$*number*?$\in$*directory*
directory′=*directory*\{*name*?$\mapsto$*number*?}
faculty′=*faculty*
rep!= *"Ok"*

We can retrieve the faculty details and finding the contact number of the particular faculty by using given below schema.

_Findnumber

$\Xi phoneDir$
name?:*person*
number!:$\mathbb{P}$*phone*
rep!:*MESSAGE*

---

name?$\in$*faculty*
name?$\in$dom *directory*
number!=*directory*$(\!|${*name*}$|\!)$
rep!= *"Ok"*

_Findname

$\Xi phoneDir$
Number?:*phone*
name!:$\mathbb{P}$ *person*
rep!:*MESSAGE*

---

number?$\in$ran *directory*
name!=*directory*′$(\!|${*number*}$|\!)$
rep!= *"Ok"*

The above schemas (Application 1) represents the storing of the faculty name and contact number of the particular faculty.

The second application saying that storing the address of the particular faculty with their contact number. Schema of second application is showing in the below schema.

_Addrdirectory

dir: *PHONE*$\rightarrow$*ADDRESS*

_Addressbook

Address:$\mathbb{P}$ *ADDRESS*
dir:*PHONE*$\rightarrow$*ADDRESS*

---

dom *directory*$\subseteq$*Address*

_Addressbook′

Address′:ℙ *ADDRESS*
Addrdirectory′:*PHONE*→*ADDRESS*

dom *directory*⊆*Address′*

_ΔAddressbook

Address,*Address′*:ℙ *ADDRESS*
Addrdirectory,*Adddirectory′*:*PHONE*→*ADDRESS*

dom *directory*⊆*Address*
dom *directory*⊆*Address′*

_ΞAddressbook

Δ*Addressbook*

Address′=*Address*
Addrdirectory′= *Addrdiectory*

The schema *Addressbook* is the main directory in which can store the details of address along with contact number. *Addaddress* represents the adding of address. The address will add automatically if it does not exist already, otherwise, we will get the message like address already exist. The schema of the above explanation represents like,

_Addaddress

Δ*Addressbook*
Addr?:*ADDRESS*
rep!:*MESSAGE*

Addr?∉*Address*
Address′=*Address*∪{*Addr*?}
Addrdirectory′=*Addrdirectory*
rep!= " *Ok*"

_Addressexist

Δ*Addressbook*
Addr?:*ADDRESS*
rep!:*MESSAGE*

Addr?∈*Address*
rep!= "*Address alerdy exist*"

The given schema represents that adding total entry into the directory *Addressbook*. Here also we will get the already existing message once it already exists, otherwise, it will add in to the directory.

_Addaddressentry

Δ*Addrdirectory*
Addr?:*ADDRESS*
Number?:*PHONE*
rep!:*MESSAGE*

Addr?∈*Address*
number?→*addr*?∉*Addrdirectory*
Addrdirectory′=*Addrdirectory*∪{*number*?→*addr*?}
Address′=*Address*
rep!="*Ok*"

_Entryexist

Δ*Addrdirectory*
Addr?:*ADDRESS*
Number?:*PHONE*
rep!:*MESSAGE*

number?→*addr*?∉*Addrdirectory*
rep!= " *Entry Alreay Exist*"

The schema *FindAddress* in which we can retrieving the address by using the contact number.

19

_FindAddress

Ξ*Addrdirectory*
number?:*PHONE*
Addr!:*ADDRESS*
rep!:*MESSAGE*

---

number?$\in$dom *Addrdirectory*
Addr!=*Addrdirectory* ⦇*number*?⦈
rep!="*Ok*"

The total schema of linking address to the phone number is,

Link address to number $\triangleq$ Addaddressentry $\cup$ Addressexist $\cup$ Entryexist

The 'Z' schema is very relevant and easily to understand. The static and dynamic characteristics of a system are described by Z schema. The states, relationship between states, some possible operations, and relationship those operations are can tell as static and dynamic characteristics of the system.

Consider, every application a separate development project. There are many reasons to introduce the new applications or projects with extended features i.e., maybe cost effective for development and maybe requirement specification. Now a days the pragmatic of software engineering become very expansive. It either has to chuck the old application or software and it includes some new features to improve the application.

Most of the time information security problem will happen at the end of execution of the application. In this case study, there are some issues while authenticating whether the given address is correct or not. The enhanced done in this application to improve the authentication that linking the Aadhar Card to each and every faculty member by using their address. So that the issue in this case study can easily recover.

The below Z schema represents the linking of Aadhar Card with faculty address. *Aadhardirectory* is the main directory of this application.

_Aadhardirectory

dir: *Address*↔*Aadhar*
MESSAGE ::= "*Ok*" | "*Already Exist*"

The *Addaadharentry* schema is using for adding the Aadhar number and Address. *Findaddress* represents retrieving the address by giving input as an Aadhar number.

_Addaadharentry

Δ*Aadhardirectory*
Anumber?:*AADHARNUMBER*
Addr?:*ADDRESS*
rep!:*MESSAGE*

Addr?$\in$*Address*
Aadhardirectory′=*Aadhardirectory* $\cup$
{ *Addr*?→*Anumber*?}
rep!= "*Ok*"

_FindAddress

Ξ*Aadhardirectory*
Anumber?:*AADHARNUMBER*
Addr!:*ADDRESS*
rep!:*MESSAGE*

---

number?$\in$dom *Aadhardirectory*
Addr!=*Aadhardirectory* ⦇*Anumber*?⦈
rep!="*Ok*"

Like this, every software must authenticate the data which can enter into the application. Not only in terms of data, even must verify in terms of the product also. Whatever verification or

authentication is to be needed, must be done before itself or while giving the specification in the top level of the process. Finally, we can identify the authenticated and non-authenticated persons separately.

Integration plays a key role in this case study to get the complete product and can access easily.

Because of formal specification, it appears that it is a seamless integration here we are not calling the additional module and not built other version of the software but it works seamlessly. The advantage of having formal specification is second application is more or less similar to the first one with something more. In the field of software engineering, we faced a lot of troubles many times because of this type of problems. The formal specification will definitely improve the way we are dealing with evolving software specification. It appears easily connectable. If only all application developers are used this formal specification within less span of time we would say that they all similar. We don't have worry about what they are used, but by the formal specification, all application developers would think that all applications are same under a product. This is the way software specification evolves for every integrated application.

The application development method has become very dominant because we are working on shorter life cycles. In this case study, the address book data is integrated with the existing phone number of faculty. Data level integration is playing the key role in this work and consequently all levels of integrations like method level, applications level, architecture level, formal level and so on.

To integrate different applications, one has to consider all levels of SDLC [Software Development Life Cycle] and levels of EAI [Enterprise Application Integration] like data level, application level, architecture level and system level and so on.

Every legacy system has been facing serious constraints in working with different modern applications. The cost of a working archived / legacy application is much higher than the changing the application. It becomes to extend the functionalities of existing projects. Here the third party maintenance plays a key role in maintaining the projects. Even though the project is under maintenance, because of high cost and more drying the project, the entire project is scrapped. Enterprise Application Integration plays a dominant role in this situation once the application has retired. Buy one more application or thinking about second application if the first application had retired is a common solution. But some sunken work in the first application can be used in the second application.

This case study would deal with the importance of application integration and evolving software specification in which the applications are developed by formal specification language like Z. However, there are some limitations in Z formalism as an integrator in this case study.

IX. Proposed Work

The authors are working on several other case studies and how they map to the proposed levels as in Figure 6.

From the past five decades bringing the practice of software in terms of application development, integrating applications and formal methods together. The fitting into levels and mapping case studies to different levels is a challenge. There is a need for factoring the hardware architecture for supporting the formal verification of performance.

A grammar which will decide the level as in Figure 6 can result in automated verification and

proving. Context Free Grammar [CFG] [34] plays a key role in controlling functionalities of the system by using grammatical rules and it is preliminary for understanding the way formal proofs in computing are constructed. Eventually a generic formalism such as Z will be used for specifying the evolving complex systems. The integration of CFG rules and Z notation will increase the modelling power of the complex system [25]

A better understanding of the behaviour of the system is very important. Behaviour of the each object and system will change based on the requirements. Commonly, interaction diagrams are used for representing the behaviour of the system and model. Sequence Diagram and Collaboration Diagram are the two ways of representation of system behaviour [24].

It is difficult to get a complete ordering of events to match the hierarchy or levels. Hence getting the correct sequence of actions to formally prove is difficult [21] thus the Sequence Diagram becomes one of the drawbacks of Unified Modelling Language (UML) while verifying formally. In complex or large systems we can able to develop many sequence diagrams. Process Model is one of the alternate method for sequence diagram. That is the reason we are going to process view model. It deals with dynamics aspects of the system, explains the system processes and how they communicate with each other in the run time environment [12]. It addresses the concurrency, performance, scalability and so on. It is a group of activities in which all activities must work together towards a common goal.

Collaboration Model is the one which has a group of roles and connectors with some attributes [24]. It mainly defines the achieving of the goal not how could accomplish that. Actions will be done quickly and problem-solving will be faster and more effective. Reuse is one of the main usage of the collaboration model [16]. A design which is implemented by collaboration can apply in various situations also. Collaboration Model may need Service Level Agreements, Protocols, Non-Disclosure Agreements, Intellectual Property and such support systems.

Computational, Process and Collaboration (CPC) is a relatively new research area for integrating the different applications throughout the levels of enterprises and software systems formally.

Open System Interconnect [OSI] is a very successful approach in the layered architecture for Computer Networking [1]. The cost of ownership is very high in the integration. Early researchers developed request broker or resource broker models in which they connected some objects and components using Service request and Service Oriented Architectures. The emergence of IoT and Bring Your Own Device [BYOD] have been even more challenging in the implementation at the Operational levels.

X Conclusion

Enterprise Application Integration (EAI) mainly focuses on the design and implementation of the enterprise solutions. The demand for integration has motivated the rapid growth of technologies, usage of internet and development of applications with new platforms like Cloud Computing, Internet of Things [IOT] and Artificial Intelligence technologies and so on. Basics of the EAI and Formal methods including usage of formal methods in industry scenario are explained. Some research directions like Context Free Grammar, UML, Collaboration and Process Models on these topics are indicated. It is proposed that every application should satisfy all levels of EAI and must be satisfied phases of software life cycle while integrating the applications. One case study with Z specification

language representing the proposed method to integrate different applications formally is included in this paper.

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Disability Models and the Concept of Accessibility: Object-Subject Model

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***Abstract*— This article briefly presents some common disability models, three of which are briefly discussed. Then a few definitions of accessibility from different perspectives are presented. The main goal is to propose a simplified conceptual model that considers the interaction between the person as a subject with a specific object and is applicable to different subjects and objects in different contexts. The model is applicable in various fields - transport, education, cultural heritage, tourism and others. Its advantage is that it can observe the interaction between the person as a subject and a series of objects in dynamics, without being influenced by the variety of views reflecting different perceptions and attitudes towards disability.**

***Keywords*— accessibility, conceptual model, object, people with disabilities, subject.**

I. Introduction

Historically and in the context of social conditions, social order, generally accepted morality and a number of other factors, in different periods, specific views are formed regarding people with disabilities. The views form a certain attitude towards the issue, and on this basis the philosophy of politics and decisions at various institutional levels are built and applied - from the family to the state and global associations. We can call this philosophy a "model" because it structures a certain attitude and behavior. Here, some already established models are briefly discussed, and a different perspective is offered on the interaction of people with disabilities, not just with the world around them, but on a narrower and more specific scale, based on the understanding of accessibility.

II. EXPOSURE

In their article "Models of Disability: A Brief Overview", Marno Retief and Rantoa Letšosa offer nine models [1]:

- moral and / or religious - the oldest model presents disability as God's work or punishment;
- medical - the injury as a disease;
- social - disability as a socially constructed phenomenon;
- identity - the disability as identity;
- human rights model - disability as a human rights problem;
- cultural model - disability as culture;
- charitable model - disability as suffering;
- economic model - disability as a challenge to productivity;
- model of limitations - disability as an embodied experience.

There are also other models available, but those listed here are some of the most common. The main models - the medical and social - will be briefly considered, as well as the International Classification of Functioning, Disability and Health (ICF).

A. The Medical Model

The medical model considers the injury mainly from a biological and medical point of view as a biomechanical problem, caused by illness, trauma or other factors, requiring prevention and medical care in the form of treatment and rehabilitation. The model is strictly normative. The individual is perceived as incapable of functioning as a healthy individual would. In other words, the disability, according to the model, is a state of health, difficulty, inability to perform an activity in a normal way.

The contribution of the medical model is in the strive of returning the body back to a normal healthy state. At the political level, it contributes to the provision of health care and medical rehabilitation. Some negative aspects of this model are the consideration of the individual as

an object to which it shows condescension.

B. The Social Model

On the other hand, the viewpoint of the social model is related to the issues of civil rights and social integration, the focus is on the environment and living conditions. From an object, the individual with a disability is transformed into a full-fledged subject. For the better functioning of people with disabilities, not only prevention, medical care and rehabilitation are important, but also the possibility for their free, safe and unimpeded movement in the architectural environment, as well as the attitude of society towards them. It can be said that the social model considers disability as a social phenomenon caused by public attitudes. Therefore, disability is not an attribute of the individual, but is a creation of the social environment and requires social change. This change has been gradual, happening over decades and thanks to various movements for the rights of people with disabilities and their public campaigns, as well as through relevant legislation. In fact, it is the social model that underlies modern legislation on people with disabilities.

C. The ICF Model

However, neither model provides a fully adequate answer to the question of what disability is. Although both points of view are justified, neither of them fully presents the complexity of the problem, as some aspects of the disability are internal and others external. The International Classification of Functioning, Disability and Health (ICF) model is a kind of compilation between the models presented above, combining them in such a way that the disability is presented as a result between the interaction of the environment and the individual with a specific health condition. It can be defined as a bio-psycho-social model. Figure 1 shows the multilayer interactions according to ICF.

Functioning is presented in three dimensions:

1. Body dimension. Two classifications are included here - one for the functions of the body's systems and the second for the structure (organs) of the body. In fact, this is an anatomical and physiological classification of the organism. This level is entirely medical and clinical.

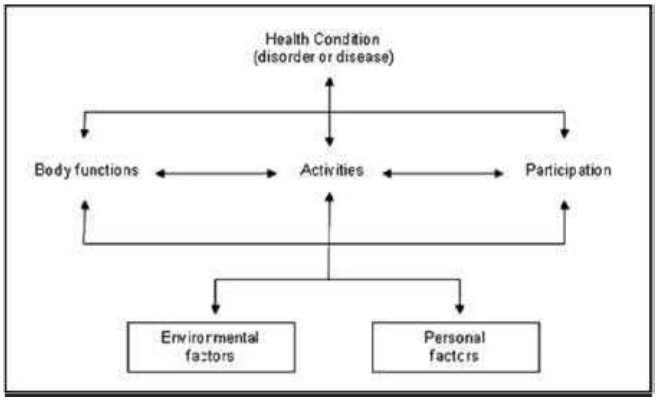

Figure 1. The ICF components and their interactions

2. Activities dimension. This includes all the actions that are specific to the individual, and the relevant parts are organized from simple to complex actions.

3. Participation dimension. Here the areas of life in which each individual usually participates are classified, to which he has access and / or for which there are opportunities or barriers [2].

D. Defining Accessibility

Regardless of the considered model, the main reason for its existence is the presence of people with disabilities. Characteristics of a specific condition form the corresponding needs. They are diverse in nature and scope, covering all aspects and activities, regardless of personal or public roles and commitments. The conflict between needs and reality raises the question of access to information, services, buildings, etc.

Just as the understanding of disability, so the definition of accessibility depends on the context in which it is considered - physical (architectural), transport, digital (web, software), sensory (museums, galleries).

The Oxford Online Dictionary of English defines accessibility for people with disabilities as a quality that allows easy access, penetration or use [3]. The definition of the Cambridge edition is similar [4].

ISO 9241-11: 2018, Ergonomics of human-system interaction - Part 11 defines accessibility

as “the extent to which products, systems, services, environments, tools can be used by a population with the widest range of consumer needs, characteristics and ability to achieve specific objectives in a specific context of use” [5].

The term “use context” includes both direct and accessible technology-mediated use.

Here, "accessible" is used not in the sense of "available" or as "accessible", but in the sense of a characteristic of documents or websites, determining their compliance with the standards for accessibility and usability by people with disabilities.

Accessibility is not a concern for a particular social group or category, but an important prerequisite for improving usability by all people. This is not "an act and not a state, but a freedom of choice, giving the opportunity to enter an environment, to move in it, to communicate with it or to take advantage of situations" [2].

The EU Disability Strategy 2010-2020 defines accessibility as "equal access to the physical environment, transport, information and communication technologies and systems (ICT), and other structures and services" [6].

Directive (EU) 2016/2102 addresses more specifically web accessibility, defining it as “principles and techniques to be observed in the design, creation, maintenance and updating of websites and mobile applications in order to make them more accessible to consumers, and in particular for people with disabilities” [7].

E. Subject-Object Model of Accessibility

It is important to note that accessibility is not limited to the possibility of access to a building, premises, vehicle, information, etc., but the degree of real possibility for their assimilation and use. For example, can a person with a visual impairment not only buy a newspaper, but also be able to read it, a person in a wheelchair not only to move successfully and safely to the bus stop, but also be able to get on a bus on public transport, a person with complete deafness not just to watch a movie, but to be able to fully perceive and enjoy the content, or a person with cognitive disorders not just to read, but also to understand at least the basic idea of a specialized scientific text. From the contextual situations considered here, access to a ‘living being’ is completely excluded in the sense of whether the boss is available for conversation, whether he is currently in person, etc.

Having and accessing an object or content does not automatically make them accessible. An example situation is considered in which a computer configuration and an operator are in the same room. The operator is located in the same room and his access to the configuration is not limited. But the fact that a computer system is available is not enough. In order to use it, a number of conditions must be met:

- Connection to the electrical network and the presence of electricity with normal parameters;
- Correct connection and serviceability of all hardware components;
- Installed and working operating system (OS).

The assumption is that all three conditions are met. The following few questions would give a realistic idea whether the operator can perform a specific task.

Can the operator perform the task if:

- is not trained to use the installed OS?
- the software needed to complete the task is not available?
- one or more of the input / output devices or peripherals (mouse, keyboard, monitor, printer) are defective and cannot be replaced?

Therefore, accessibility can be considered schematically as an interaction between two factors. On one side is the object or information with certain characteristics, and on the other side - the user as a subject also with specific characteristics. Taking this into account, we can distinguish both sides of accessibility: accessibility of the object (object accessibility) and accessibility according the subject (subject accessibility).

There is a wide variability and intersection with the concept of usability, as the subject is measuring the object accessibility. If for one operator the console OS is a problem, respectively it is inaccessible and unusable for her/him due to the lack of acquired skills to work with it, then for another who has the necessary skills, there would be no difficulty, i.e.

it would be accessible and usable. In short, the object accessibility is characterized by the availability and serviceability of the object, and the subject is characterized by the ability of the subject to perceive, understand and use the object.

However, subject accessibility is not always in direct relation to the subject's knowledge and skills. There are many factors that work individually or in different combinations, and to a varied degree can affect and even hinder the usability and understanding of the object. Such examples can be physical, sensory and cognitive disorders. They may distort the functionality to the extent that a certain amount of compensation is required on the part of the subject to achieve a balance with the generally accepted norm. When this is unattainable on the part of the subject, modification of the object is resorted to. An example of this is the change in vision. In farsightedness, physiological changes in the visual analyzer are compensated by other optical means - magnifiers, lenses, glasses. When this level of compensation proves insufficient in case of further visual impairment, a change of / object (environment) is applied - an additional software magnifier can be installed for better perception of the visual information. If the visual impairment progresses and it is impossible to see the picture on the monitor, then it is compensated with another type of software - screen reader. If severe hearing loss occurs to the point where audio feedback cannot be received, the only possible compensation is the refreshable braille display. However, if the sensitivity of the fingers weakens to the point where Braille cannot be used, then there is a practical impossibility of further compensation. The conclusion is that, although advanced, at present, technologies do not offer a universal and sufficient possibility to compensate or restore functioning within the generally accepted framework in all cases [8].

Although technological solutions are not a panacea, they can undoubtedly provide high-quality and sometimes even irreplaceable help to those who need it. This brings us to the topic of assistive technologies. They are largely responsible for compensating for limited or completely missing operational capabilities. These can be low or high-tech products in the form of hardware or software. As there is no definition of auxiliary technologies in the Bulgarian legislation, definitions from foreign theory and practice are used. The first examples are definitions of US law. The Technology-Related Assistance Act of 1988 (PL 101-407) [9] and the Accessibility Technology Act of 1998 (PL 105-394) [10] offer a standard definition of assistive technologies, defining them as “any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities”.

On one hand, it is about equipment for the benefit of people with disabilities, and on the other, about the process of facilitating the use of equipment by the same people. Thanks to these technologies, the spheres of independence are expanded, the opportunities for participation are improved and in general their quality of life is improved, facilitating or making possible activities difficult or impossible before.

However, there is also a variant in which the adaptation of the subject to the object reaches its maximum potential and the subject is hindered to the extent of difficulty or complete impossibility. The subject does not have more means to adapt to the site and does not have mechanisms to adapt the site to its preferences and capabilities. Examples are the lack of elevators or wheelchair ramps, the lack of platforms convenient for the elderly and people with reduced mobility, and the lack of software and websites that are not built according to good practices and accessibility standards, resulting in information and interface presented in inappropriate and inaccessible way to the assistive technologies, which makes their use difficult or even impossible.

So, on one hand is the object, on the other - the subject, which has the means to adapt, but also the objective impossibility to influence the object. There are barriers that can be overcome by means of partial or complete adaptation and barriers that require site changes.

As mentioned above, the subject is the one who

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measures accessibility. A set of specific standards, guidelines and criteria serve as tools for independent measurement. It is not necessary to use them only by people with some kind of disability. Each of these measures (indicators) has its own specifics, consistent with the area for which it is intended and used.

The overlap of separate requirements to the objects and the information is inevitable due to the similarity of their characteristics in their different incarnations. For example, the requirement for a certain ratio of the contrast between the main and background color is valid for both print media and electronic media. And since they can take a different form, this is even more important. If in certain transformations certain characteristics can be changed in advance, then in others there is a restriction to influence the final product. What is meant by this? If after the transition of an image from physical to digital form the final characteristics such as color, brightness, etc. can be changed. Printed on paper, it is considered as a final product, as it can no longer influence the characteristics that have already taken physical form.

Full or partial inaccessibility exists when both the object and the subject cannot adapt to each other at all or in part, and this leads to complete or partial impossibility of use for the object by the particular subject.

Optimal accessibility we call the consistency of the characteristics of an object with the capabilities and understanding of the widest possible range of subjects.

Full accessibility is present when the object is adapted to the greatest extent to the peculiarities of the perceptions, possibilities and understandings of a subject.

When the totality of all objects and the whole volume of information meet this requirement, there is perfect accessibility. At the moment, it is a purely theoretical statement of logic with the "ideal competition" in the economy - such is not practically achievable, at least in the foreseeable future.

III. Conclusion

There are several views on the problems of people with disabilities, called 'models', but they address issues not so much of interaction as of different perspectives on attitudes towards people themselves and rather on perceptions of disability. However, none of them considers human interaction as a subject with a specific object. The proposed model considers on a smaller scale the interaction between a person with a disability and an arbitrary object.

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GDPR – General Data Protection Regulation on Sites Requiring Accessibility

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***Abstract* — This paper describes what GDPR - General Data Protection Regulation is and why it matters for business, institutions and other legal entities, who need to collect personal data in order to provide and deliver services or products. They have to apply and describe to the consumers the principles and general rules to protect their data. Rules include reasons why personal data collection is necessary, transparency how and by whom it will be used and stored and for how long, as well as safety measures to not be used by other third parties or for other purposes unless the consumer clearly agreed.**

The paper explores the necessity and awareness to provide personal data to sites, how people provide it, what rights and options there are to protect it and why. Online users and clients are now more aware and receiving information on how their personal data is used by sites and service providers online. Research results on the extent people want and fear to share their personal data are also presented.

The paper presents in detail GDPR rules, requirements, rights and practices, as well as what is personal data and sensitive personal data and the different ways to process and protect it. The research also focuses on special personal data provided by people with disabilities in order to have accessibility on sites and use certain services. In the end, recommendations for sites with accessibility are presented, following GDPR protection requirements.

***Keywords* — accessibility, breaches, collecting data, disability, data bases, GDPR, Internet, personal data, processing, protection, regulation, sensitive data, security, services, rights, sites.**

I. Introduction

In 1998, a law was introduced in the EU about how your personal information needs to be protected. This law is called the Data Protection Act. Since General Data Protection Regulation 2016/679 (GDPR) EU law on data protection and privacy in the European Union and the European Economic Area came into force in 2018 companies, authorities and all legal entities have been struggling to comply. If they fail to achieve GDPR compliance, they are subject to potential lawsuits, data leaks, penalties and fines. GDPR requirements apply to each member state of the European Union, aiming to create more consistent protection of people's personal data across the EU.

In practice, most of the sites collect personal data to function or provide a service, including news sites and the social networks, which most of the people use. Online users should agree their data to be collected and saved in order to be able to use the service.

In order to correspond better to consumer needs and preferences, more sites are made with a programming code that detects what a user likes and wants. For example, if you buy baby goods via your Apple phone, then the site owners would most likely know that you are a parent of a newborn child, aged between 20 to 45 years old, using smartphone internet and applications and likely to buy expensive and complex technological household products. Having this data, a site or related site, social network page and service provider can offer you automatically (often without your understanding) other suitable products and services for a parent of this age in the specific location. Providers of movies and video like Netflix and You Tube also have programming code that detects what you like to watch most often and offers you other similar content. Generally, that makes the consumer happy, because he or she receives offers that are more suitable to him/ her, but what happens when the consumer does not want his actions and preferences online to be known and used by sites, their owners or third parties? What happens if their detected preferences and personal data are misused? Moreover, sensitive data containing race, religion, ethnicity,

disability, mental health condition or certain group memberships, can be used for disqualification and discrimination of people, when they apply for a credit, insurance, job, rent or something else.

A Visually or hearing impaired person often needS to notify the programming code of a visited site, that he or she has disabilities, by clicking a button or link, in order to see a specific content, which makes the site or service online accessible for him or her. The impaired user is not always explicitly asked to provide this personal data, as the site code detects and follows site clicks and actions and this way it makes analytical conclusions about the people using the site. This raises moral, ethical and legal questions and concerns many entities – companies, institutions, clients, marketing and software development experts.

Sites with accessibility should be especially careful and have protective mechanisms to not violate GDPR, to not misuse the collected sensitive personal data or have a software weakness and breach, enabling others to misuse it.

To explore this matter further, the paper will present in detail GDPR rules, requirements, rights and practices, as well as what is personal data and sensitive personal data and the different ways to process and protect it. In the end, the paper will present recommendations and good practices for sites with accessibility, following GDPR protection requirements.

II. Exposition

Digital world made it possible for large amounts of data to be easily collected, stored, transferred and used or misused. A misusage of stolen data from not well protected sites and servers can lead to great damage for the individuals concerned and even change political, social and economic environment in a country. As the hacker attacks increase [1] and the threat grows, this also increases the concern of people, public and governments and the need to be more aware and protect better personal data. Data leaks and breaches in security can harm significantly not only individuals, but also the image and financial state of the sites and data controllers concerned, due to media scandals and lawsuits.

1. Personal Data Leaks

The most common reasons for data breaches and leaks include: malware, weak, guessed or restored passwords with weak authentication methods on one level, fishing emails with false misleading data, software vulnerabilities - poorly designed or flawed software applications or not enough secure cloud connection sharing data system, unauthorized access or unauthorized and consented transfer of data to third parties, not related to the reason this personal data is collected and processed.

A 5.1 million BGN penalty was imposed in 2019 to the Bulgarian National Revenue Agency for the breach of personal data of 4,1 million Bulgarian citizens. Many citizens believe this penalty and protection measures were not enough, as in 2020 there were new attempts for online fishing breaches of people and companies with a fake email sent with BNR's domain name - nra.bg.

If access control is not adequate, it can also easily lead to a data breach. In July 2019, the Dutch Data Protection Authority (DPA) issued the country's first ever GDPR healthcare related fine [2]. The Hague's largest hospital, Haga Ziekenhuis, was fined €460,000 for failing to secure the personal data of one of their patients. The Dutch DPA stated that at least two of the hospital's security measures were insufficient. Not only did the hospital fail to alert administrators that an unauthorized employee was looking into personal files, but the hospital also failed to use a two factor authentication for accessing the database itself. 620 million accounts were stolen in 2019 from 16 hacked websites and they were subsequently sold on the dark web.

Facebook announced a massive security issue affecting at least 50 million users on 09.25.2018. Afterwards, on 19.12.2018, Facebook gave some companies more extensive access to user's personal data than it has previously revealed, letting them read private messages or see the names of friends without consent, according to a

New York Times report [1]. Facebook is facing also international investigations into the illicit harvesting of about 87 million users' personal data and then developing a software program that profiled those citizens to predict voting patterns and, through micro-targeted ads, influence US citizens' voting decisions. Facebook's Personal Data Tracking and usage for advertising purposes has also been a concern since long and governments are now trying to do more about limiting this tracking data collection and protecting the user more.

YouTube is also struggling in the last 2-3 years to refine and improve their advertising policies and methods, as they also record and use behavior and preference related data, collected from user accounts.

In 2018 Google engineers discovered a software leakage within the Google+ API used in the social media network. As over five million user's data was compromised, this led to the immense news coverage on consumer privacy levels within Google+ and the shutting down of the Google+ consumer social network on 2 April 2019.

On 20.11.2018 an Instagram software bug, connected to their GDPR and data protection tools, exposed many user passwords.

On 01.08.2018, Reddit said an attacker breached several employee accounts in mid-June.

In May 2018 Twitter asked 336 million users to change their passwords after the company recently discovered a bug that stored user passwords in plain text in an internal system.

2. GDPR – General Data Protection Regulation

„The Regulation lays down rules relating to the protection of natural persons with regard to the processing of personal data and rules relating to the free movement of personal data. Protects fundamental rights and freedoms of natural persons and in particular their right to the protection of personal data [3]." It makes sure that personal data in the EU is collected in a fair, responsible and lawful way by data collectors and processors. It also prevents organizations from collecting more personal data than they actually need in order to provide the certain service. For instance, you don't need to tell an e-commerce online shop your gender or nationality when you buy a camera or kitchen appliance products. Data controllers are organizations, institutions, companies and data processors are their suppliers. They often use personal data to deliver products and services and they must both ensure that the data is managed safely and securely. Sometimes data processors receive the requests and may have to help data controllers fulfill them. Under the GDPR the persons, whose data is used, are data subjects and they can check and control how their data is being used and if it is safe enough. These controls are the new rights for data subjects. Data controllers have a legal obligation to respond to requests from data subjects and provide information on how their data is handled.

Protecting rights of people

The new law outlines specific rights for individuals (Figure 1) – subjects of personal data, concerning processing their personal data or GDPR rights. It also makes sure these rights are followed.

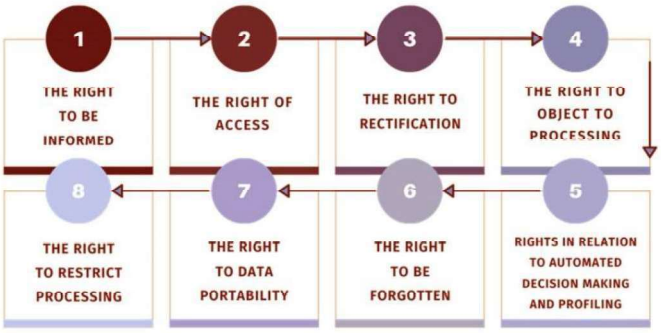

Figure 1. GDPR rights of people

1. The right to information – the right to be informed about the processing of their data. Data controllers have to give clear and concise, understandable information in this regard. It includes also requiring the consent of subjects for data processing.

2. The right to access of personal data free of charge and in an accessible format.

3. The right of rectification – editing, renewing with up to date data, completing the data.

4. The right to object processing of their data or part of their data if they have not given their consent.

5. The rights in relation to automated decision making and profiling.

6. The right to be forgotten - erasure of collected data, right to be forgotten/deleted, used only for a certain period of time.

7. The right to data portability of personal data to themselves or to another controller.

8. The right to restrict processing – to stop processing data for certain things.

GDPR also includes the following *requirements* to data handlers:

- Consent of subjects for data processing
- Providing data breach notifications
- Safely handling the transfer of data across borders
- Requiring certain legal entities to appoint a data protection officer to oversee GDPR compliance
- Anonymizing collected data to protect privacy

3. Understanding and Consent to Sites Collecting Data and Using GDPR Protection by People

According to Eurostat's 2020 Community Survey [4] on Communication Technologies (ICT) and their usage in households and by individuals, 1 in 2 people aged between 16-74 years refused to allow the use of their personal data for advertising purposes, when using the internet for private purposes in the preceding 3-month period. Moreover, 46% reported that they only allowed restricted access to their geographical location, or refused access to this information entirely. Only 40% of EU citizens read privacy policy statements before providing personal data. Similarly, 40% have limited access to their social networking site profiles, content or shared online storage. Meanwhile, only 33% checked that the website where they provided their personal data was secure. The highest results on private data usage trust in sites were observed in the Netherlands (73%), Finland (70%), Denmark and Germany (both 63%), and Spain (62%). In contrast, the lowest shares were recorded in Bulgaria (10%), Romania (20%), Greece (29%), Slovakia (30%) and Latvia (32%).

Pew Research Center's survey [5] about personal data shows that 81% of Americans think the potential risks of data collection by companies about them outweigh the benefits. 77% of Americans say they have heard or read at least a bit about how companies and other organizations use personal data to offer targeted advertisements or special deals or to assess how risky people might be as customers. 79% of Americans are not confident about the way companies will behave when it comes to using and protecting their personal data. Roughly 7 in ten or more say they are not too, or not at all, confident that companies will admit mistakes and take responsibility when they misuse or compromise data. Akamai Research shows that 54% of the respondents are highly likely to walk away from a business that requires them to provide highly personal data (such as email or phone number), in order to conduct business with them.

One of the results in Emarketer's e-commerce research is that 80% of the respondents stated they would be comfortable sharing personal information directly with a brand for the purposes of personalizing marketing messages. However, only 16.7% said they would be OK with sharing this type of information through third parties.

From all stated research we can make the suggestion that the majority of users, who know that their personal information is collected and used, when they visit a site and receive a service or product, via cookies or other software and data collection method, are ok for their information to be used, as long as it is secure, not misused and not shared with third parties for other purposes without consent.

Personal data collectors should put more effort in securing their sites and developing GDPR protection mechanisms in order to keep the trust of the people.

4. Definition of Personal and Sensitive Data and Bases for Processing

Personal information or personal data is any information about a person that identifies him/her in any way as an individual. People can be

identified or classified by many criteria, not only by their name. Their characteristics and personal data are protected by personal data rights and not meant for everybody to know. *Personal data,* subject to GDPR protection can include, but is not limited to:

1. Name, identification number and documents
2. Family and demographic information – age, sex, location, marital status, children, etc.
3. Fingerprints, signatures and genetic information
4. Health information and state, medical records
5. Financial information
6. Home and work information
7. Online and offline behavior patterns and interests
8. Used devices and IP addresses
9. Economic, cultural and social identity
10. Leisure activities and hobbies
11. Travel history

Organizations do not always need to seek consent to process personal data. Consent is only one of six lawful grounds for processing personal data according to Article 6 in GDPR law [3], and the strict rules regarding lawful consent requests make it the least preferable option.

There are six lawful bases for processing personal data[3]: 1) giving consent for processing with certain purpose; 2) processing is necessary for a contract; 3) processing is necessary for compliance with a legal obligation to which the controller is subject; 4) processing is necessary in order to protect the vital interests of the data subject or of another natural person; 5) processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority; 6) processing is necessary for the purposes of the legitimate interests pursued by the controller or by a third party (for example for insurance or debt payment). However, consent is needed to process sensitive personal data [3]. Sensitive personal data should be protected better than other personal data. It is often encrypted and/ or pseudonymised [6].

Sensitive data includes the following information about an individual:

1. Sexual orientation and life, gender reassignment
2. Disabilities, as well as health and mental conditions (includes pregnancy)
3. Union memberships
4. Political opinions and group memberships
5. Religious beliefs, race, ethnic origin
6. Genetic and biometric data

If an organization has identified that the data they are handling is or could be special category data, then they need to comply with the requirements under Article 9 of the GDPR [3]. Conditions for processing special category data are:

(a) Explicit consent
(b) Employment, social security and social protection (if authorized by law)
(c) Vital interests
(d) Not-for-profit bodies
(e) Made public by the data subject
(f) Legal claims or judicial acts
(g) Reasons of substantial public interest (with a basis in law)
(h) Health or social care (with a basis in law)
(i) Public health (with a basis in law)
(j) Archiving, research and statistics (with a basis in law)

Substantial public interest conditions may include: statutory and government purposes; administration of justice and parliamentary purposes; equality of opportunity or treatment; regulatory requirements; preventing fraud; insurance; political parties; support for individuals with a particular disability or medical condition; Counseling. Understanding of substantial public interest conditions may vary in different countries and practices and is yet to be understood better in practice.

Sites in the health care sector, both private and public, containing sensitive data of vulnerable individuals must provide more protection to sensitive personal data and pay special attention to GDPR regulation. With the help of cloud-based technology, systems containing patient data are often transferred or shared among hospitals, institutions, GPs, pharmacies in order to serve patients best. But how should this sensitive data be processed and shared according to the GDPR?

For example, a cloud-based system often used within healthcare is the Dutch MedMij, which

creates a personal health environment (PHE) to manage and share medical data. It involves a set of agreements between stakeholders like software developers, healthcare providers and patients, as well as a financing system and information standards, to facilitate data sharing and also mitigates concerns around data privacy, awareness, and interoperability.

Points of access and double authentication of authorized personnel is also necessary to prevent breaches in information security. Regular software checks should be done and notifications must emerge automatically if there is an unauthorized access, suspicious data transfer or breach in security. Sharing data to third parties should also have lawful basis and/ or consent.

5. Definition of Web Accessibility

Web accessibility means that websites, tools and technologies, are designed and developed so that people with disabilities can use them. More specifically people can: perceive, understand, navigate, and interact with the Web; contribute to the Web; Web accessibility encompasses all disabilities that affect access to the Web, including: auditory, cognitive, neurological, physical, speech, visual (Figure 2).

Figure. 2. Types of Disabilities, Source: https://commons.wikimedia.org/wiki/File:Disability_symbols.svg

Visual impairment includes a partial or total inability to see or to perceive color contrasts.

Hearing impairment includes not just deaf people, but also people with reduced ability to hear.

Motor or physical disabilities: People with difficulty moving parts of their bodies, including making precise movements (such as when using a mouse).

Photosensitive seizures: Conditions such as epilepsy can cause seizures that are often triggered by flashing lights.

Cognitive disabilities: There are also many conditions that affect cognitive ability, such as dementia and dyslexia.

To work around these issues, many people use assistive technologies and software to browse the internet. This includes screen readers that vocalize the text on each page, speech recognition software that converts speech into text, Braille terminals, and even alternative keyboards that accommodate special needs.

As disabilities can vary a lot it is hard and nearly impossible to make a site accessible for all types of disabilities. Most of the sites focus on providing suitable content for people with visual, hearing impairment and people who might have photo sensitive seizures or mental vulnerability to sensational, shocking, depressing or violent content.

According to Eurostat statistics in 2017 a quarter of the EU population aged 16 or over reported long-standing disabilities [4]. This means that they felt some, or severe limitations in performing their everyday activities for a period of six months or longer. The EU and its Member States are committed to improving social and economic situation of persons with disabilities. Respectively this will affect not only institutions, but also service providers and organizations. Internet and sites must be accessible and provide equal access and equal opportunity to people with diverse abilities. Accessibility supports social inclusion for people with disabilities as well as others, such as older people, people in rural areas.

6. Recommendations for Making Websites More Accessible and GDPR Compliant

The following recommendations were gathered for making websites more accessible, using analytical research reviews of sites with accessibility, as well as frequently outlined points by web developers [6] and specialists about GDPR and disabled people for testing.

It is necessary to determine GDPR requirements on the site before it is even designed, if that is possible. It is harder to redesign already existing, complex cloud

connected sites and platforms in a way that they can comply with GDPR multilevel personal data security requirements. Transfer of data to new sites or systems can also be challenging in terms of security and preventing breaches.

6.1. GDPR Compliant Site Recommendations

Sites of organizations should be more *simple and functional* than flashy and beautiful in order to comply with both GDPR and accessibility.

Content should be well organized and not neglecting impaired people's needs. It is better that they would not need to find a special button in order to be sent to another singular page or content, which is only accessible. First, this way it is harder for them to reach the content, second it may not have the full actual content and functionality of the rest of the site and third, separating vulnerable, disable people's content from the rest of the site content can pose a threat for GDPR related personal and sensitive data usage.

Sites should collect less data of the users or only the necessary data in order to fulfill their services. Every unnecessary additional data for marketing purposes can be questioned and judged in court if used for other purposes and the person did not allow this explicitly with consent.

Informing consent forms and revoking forms for personal data usage, *cookies usage and general regulations pages* on the sites must be easy to enter, understand and use in any moment. Visually or motor impaired people often have difficulties with pop-up windows on sites. Using such pop-up windows is a common practice that should be reconsidered or improved.

Methods for secure storing, protection, processing and transfer of personal data on sites must be implemented and consulted with a GDPR lawyer or specialists while sites are developed or improved. Double access authentication security measures and processes for updating personal information are recommended for users on the sites to protect their data.

Collected information on sites should be used only for the reasons it is initially collected and by the same legal entities. When public interest is in place or statistical usage of the information then individual values of the information should be *pseudoanonymized* [7].

Personal data must not be collected and stored longer than needed. For example, if the personal data is given for applying a credit, then this personal data must be deleted after the individual has paid and covered in full the credit or the individual should agree again when closing the credit, for personal data to be used further by the collector for marketing purposes.

A site or platform must have a clear and easily accessible process for *revoking and deleting personal data* if demanded by the user and not necessary for further services, statistical or legal reasons or public interest.

Sensitive data can, and in many cases must, be *pseudonymized or anonymized.*

The GDPR does not apply to anonymous data, which means that such data can be used more freely. Anonymization of personal data means that data will no longer be linked to an identified or identifiable natural person and therefore not be considered as personal data. Anonymization is a method that replaces original clear data with a value that is both unrelatable to the original data and permanently irretrievable. Anonymization is most often used when the original source of data never needs to be, or is not allowed to be, disclosed, such as in the case of a medical study.

The process of anonymization can be used for personal data protection and GDPR compliance in two main ways: 1) as part of the "privacy by design" strategic work – with the goal to improve the protection of the processed data; or 2) as part of the "data minimization" strategy – where data can be anonymized, used and transferred without the risk of harming the data subjects.

Pseudonymization is a method and technique used by site security experts or government officials to hide the personally identification information in order to maintain data structure and privacy of information and comply GDPR regulations without needing to ask specifically for consent or if data needs to be transferred to an outsourcing service data handler without disclosing the data. Pseudonymization takes identifiable data and replaces it with a value that

cannot be linked to a specific individual without additional "key" interpreting information that can be accessed elsewhere.

Pseudonymization [7] is a data management and de-identification procedure by which personally identifiable information fields within a data record are replaced by one or more artificial identifiers, or pseudonyms. A single pseudonym for each replaced field or collection of replaced fields makes the data record less identifiable while remaining suitable for data analysis and data processing. GDPR Article 25 [3] identifies pseudonymization as an "appropriate technical and organizational measure". Article 25 requires controllers to: "…implement appropriate technical and organizational measures for ensuring that, by default, only personal data which are necessary for each specific purpose of the processing are processed [3].

One way to decide whether certain personal data needs pseudonymization is to consider not the data set, but the level of access. Typically, in pseudonymized data, people cannot be identified without an encryption key. Assuming other organizational safeguards are in place, if a holder does not have the key, those data should be considered anonymized in the hands of the holder. Pseudonymized data can be restored to its original state with the addition of information which then allows individuals to be re-identified, while anonymized data can never be restored to its original state.

6.2. Information Structuring and Design of Accessible Sites

6.2.1. Structuring and Design

The accessible sites usually have soft, clear colours, without shadows and sudden colour tone shifts, suitable for people with colour sensitivities or colour perception disorders. Colours containing big amount of red and green can be not suitable for dalnonists.

Alt text description can be added to all images in order for a person with impaired vision to understand their content.

Automatic flash and lighting media must be avoided as it can be confusing, frightening, surprising and hard to turn off. For people with photosensitive seizers such flash media can be not just posing discomfort, but also a health threat.

Text should have a contrasting different colour and bigger font size. If possible, without confusing the site design and structure, text can be resizable for people with impaired vision that need bigger letters to read. Resizable text is also useful for making the site to be adjustable to different screen sizes and devices, including mobile and big TV screens.

In order to structure content on the site correctly, each field should be *clearly labeled with headers*. This helps not only for accessibility and easier finding of content on the site, but also for SEO optimization – easier finding of the site by search engines.

Forms for text writing can be designed with plug-ins like Caldera Forms builder to be accessible.

Tables design on the sites should be avoided except for tabular data, or if necessary to put such on the side then HTML markup is needed to indicate header cells and data cells and define their relationship. Site developers can use tutorials like *WAI Tutorial* [8].

Simplicity and Easy Functionality, Hyperlink connections, Search option

People with cognitive conditions and even normal people can have difficulties reading and understanding long complicated sentences. That is why, when preparing text and content on the site it should be made with accessibility in mind – simple explanations and sentences, short sentences, descriptive names where it is necessary, and more anchor hyperlink texts, less buttons and complicated design with many pictures and media.

Adding a search field on a site helps both impaired and other people to navigate and find easier information on a site. Some search fields and forms can operate also with voice control.

For the search option to be fully accessible and useful, site developers also need to make sure that all pages are indexed, and that the sorting of the search results is helpful.

Assistive Technologies for people with motor disability [9,10]

People with motor disabilities can choose

from a variety of assistive technologies to navigate in the Internet. Common motor assistive technologies include head wands, mouth stick devices, a single switch device with a large button or a touch-sensitive pad. Special software is often necessary to translate those assistive technologies into computer commands.

Eye-tracking devices are used by people with less or no hand muscle control to navigate the web.

Voice recognition software offers some users the option to navigate the web via direct voice commands smoothly. Some searches on sites, platforms and applications are also using voice recognition and control.

Most of these motor assisting technologies work with, or emulate, a keyboard interface. Despite the wide variety of motor disabilities, assistive technologies are often designed with broad purposes that can apply to multiple types of disabled individuals.

Unfortunately, assistive technologies by themselves are often not enough to make the web accessible to users with disabilities if sites do not have accessibility compatible content and design.

6.2.2. Making Sites Suitable for Only Keyboard Navigation and Usage

Despite the availability of oversized and adaptable models, people with motor disabilities often find it impossible to use a mouse. Most assistive technologies that people with motor disabilities use emulate a keyboard in some way. By making a website, platform or application *effectively usable with a keyboard*, you can also enable users of these assistive technologies, in particular by reducing the number of actions that require too many key presses, which can be complicated and tiring for people with motor impairments.

All content on the sites should be easily accessible. Tags can be put on the content of the page. Dynamic content can be tagged as a *"live region,"* which enables screen readers and similar devices to understand the content as it changes or *ARIA Landmarks or skip-to-main links*, which are invisible links that let users skip menus. It is crucial to make navigation easier as it lets users skip directly to specific content.

This way, users with impairment will not need to tab through every menu item just to get to your main content and can easily pass over other link-heavy sections. *WAI-ARIA Guidelines* can be also used for making elements on web pages accessible via keyboards and keyboard emulators [8].

Practical ways to navigate on the site with only a few clicks can include a *skip-to-the-end, skip-to-content* or search function on long pages and long lists. Another way to reduce the keyboard clicks, needed for navigation, is to *structure navigation menus as a multi-level tree*. Instead of scrolling through an entire list of available pages, users can jump to the section of the navigation that they are looking for with only a few clicks.

III. Conclusion

The recommendations above can be used for creating a methodology and good practices guidelines for accessible, GDPR complying, sites and platforms. Security of personal data and GDPR are important topics for institutions, business, international organizations, NGOs, statistical agencies and service providers, especially when they interact and transfer data or use complex cloud technology for access, which can pose security threats.

GDPR regulations are still being clarified on their meaning and practical use [11]. Some situations and cases can make precedents and this poses new legal and ethical questions on how GDPR should be applied in specific areas and situations. For example, when is public interest for processing data really valid? Or what happens if a person's consent is revoked but data has already been used and the person did not understand? What if a disabled person cannot understand or reach GDPR site's general rules and explanations about processing his personal data on a site? The common rules of the site might imply consent for processing or transferring such information to third parties but an impaired person might not understand that.

The health care sector and accessibility on sites are related to sensitive personal data and,

therefore, such sites and platforms should be especially careful for GDPR violations to vulnerable people or security data breaches and data stealing.

Another matter of concern and future research is: Where is the border between collecting data for public and personal interest, or statistical reasons, and misusing this data for something else due to the broadly written consent agreement? The matters of training of personnel concerned with GDPR, as well as finding good guidelines for software developers and managers, and defining levels of access in security systems concerned, are also important.

GDPR personal data security methods and practices applied in different sectors and institutions have to be explored further in order to show good and bad examples and how security systems and methods can be improved.

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