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Adoption Of Internet of Things (IoT): Applying Technology Acceptance Model

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Abstract: At the time of inception of new concept, theory, rule resistance from the user is expected. The technological acceptance concept is not an exception. User acceptance of technology has been an important field of study in this century due to the advancement of technology. Many models have been proposed to explain and predict the use of a system. The purpose of this paper is to study the various technology acceptance models in detail. The gist of seven models with reference to the constructs and variables is done here. The various IOT application sectors is also covered here.

The domain model, application of architectural reference model is also discussed here. For the adoption of IOT in any area, technological acceptance to be verified with specific scientific techniques. This paper has the detailed procedure of application of these methods starting from research methodology starting from research design up to data analysis, tabulation and result presentation.

Index Terms **- IoT, Technology Acceptance, Domain Model, IOT-ARM, Technology Acceptance**

I INTRODUCTION

IOT is empowering computer system so that it can see, hear, smell the world for themselves. IOT uses cognitive approaches. Due to heterogeneous nature of the resources it contains, IOT has become complex in nature. IOT needs the idea of machine learning algorithms, Data analytics, Smart Asset Management etc. One should have the basic idea of endpoints, sensors, actuators, local processing and cloud processing. IOT is a technology which is used starting from data acquisition to its consumption. It is also referred as IOE, WOT.

Key Points

- It is a data centric Technology.
- It is a system of systems.
- It is not only one technology - is a group of Technologies.
- It uses set of protocols, Communication Systems.
- It covers long range and short range connectivity too.

As it is a convergence of all the technologies, the knowledge of multiple domains is essential. Automation, Data Analytics, Cloud Computing etc.

The Internet of Things (IoT) is a technological revolution that enables pervasive interaction between objects, people and environments. Data will be gathered by embedded sensors and actuators, which are then sent to specialized applications to create actionable information.[1] IoT has been acknowledged as one of the foundation stones of Industry 4.0, due to its potential to change the existing industrial and business processes. With the advent and growth of the IoT, physical environments are becoming smarter and more interconnected than ever before. This has changed the way we live by improving sustainability, efficiency, accuracy and economy in almost every aspect of our lives. IoT has been leveraged in many industries such as healthcare systems, traffic management, energy management, education, environment monitoring, smart homes and smart cities.

1.1 IOT Application Domain:

Currently most of the industries have upgraded to industry 4.0 Standard. Thus IOT adoption is taking place in the areas such as Telecommunication, Medicine, Education, Health, Automobile, Transportation, Logistic, Science and Technology, Engineering, STEM, Infrastructure Management etc.

II OBJECTIVES

The paper is designed with the following objectives:

- To understand the development of IOT technology.
- To study the technological acceptance models.
- To compare the models pertaining to the adoption.
- To list the constructs needed for framing framework.
- To understand the procedure to be adopted for IOT adoption.

III TECHNOLOGY ACCEPTANCE MODELS

This paper describes various technology acceptance models and also lists the constructs and the general methodology for acceptance is also discussed here. The following models are discussed here, the Theory of Reasonable Action (TRA) (Fishbein and Ajzen, 1975), the Technology Acceptance Model (TAM) (Davis, Bogozzi and Warshaw, 1989), Final version of Technology Acceptance Model (TAM) Venkatesh and Davis (1996), Technology Acceptance Model 2 (TAM2) Venkatesh and Davis (2000) and Unified Theory of Acceptance and Use of Technology (UTAUT), Venkatesh, Morris, Davis and Davis (2003).

3.1Theory of Reasonable Action (TRA)

The Theory of Reasonable Action (Fishbein and Ajzen, 1975) is one of the most popular theories used and is about behavioral intention of the person's attitudes as shown in Figure 1. Fishbien and Ajzen (1975) defined "attitude" as the individual's evaluation of an object and defined "belief" as a link between an object and some attribute, and defined "behavior" as a result or intention. Attitude (A) are affected by the Beliefs & Evaluations and Subjective Norm (SN) affected by Normative Belief. The actual behavior is affected by the behavioral intention (BI). [2]

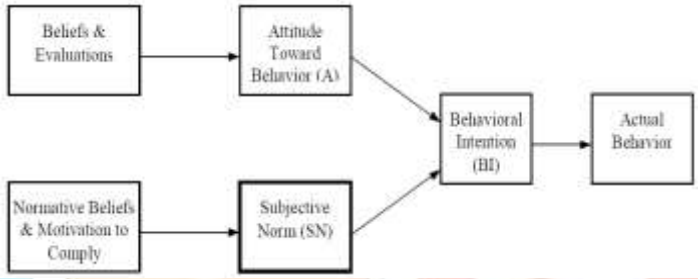

Figure 1. Theory of Reasonable Action (TRA)

3.2 Theory of Planned Behavior (TPB)

Ajzen (1991) developed Theory of Planned Behavior which is about one factor that determines behavioral intention of the person's attitudes toward that behavior as shown in Figure 2. The first two factors are the same as Theory of Reasonable Action (Fishbein and Ajzen, 1975). The third factor that is known as the perceived control behaviour (PCB) is the control which users perceive that may limit their behavior. [3]

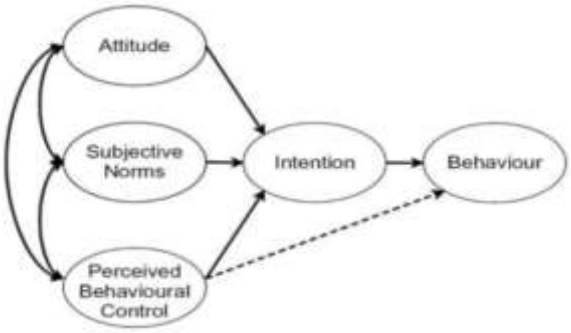

Figure 2. Theory of Planned Behavior (TPB)

3.3 Original Technology Acceptance Model

Technology Acceptance Model (TAM) was introduced by Fred Davis in 1986 as shown in Figure 3.
An adaptation of Theory of Reasonable Action, TAM is specifically tailored for modeling users' acceptance of information systems or technologies [4]. It has constructs such as Perceived Usability, Perceived Ease of Use [5], Attitude and Actual Use. Also it shows the influence of variables on PEOU, PU constructs.

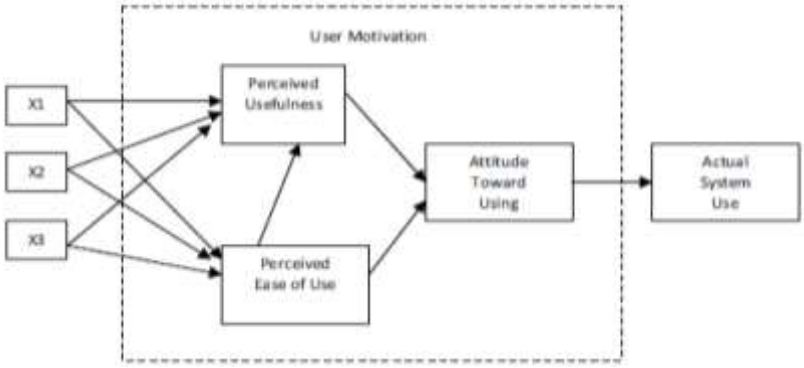

Figure 3. Original Technology Acceptance Model (Davis, 1986).

3.4 Modified Technology Acceptance Model

Technology Acceptance Model (TAM) was introduced by Fred Davis in 1986. Later in 1989 Davis and others have modified the model by adding the new construct called Behavioral Intention (BI) as in Figure-4. The model has seen another change in variables sector. The new construct called External Variables is used to represent the consolidated list of variables. [6]

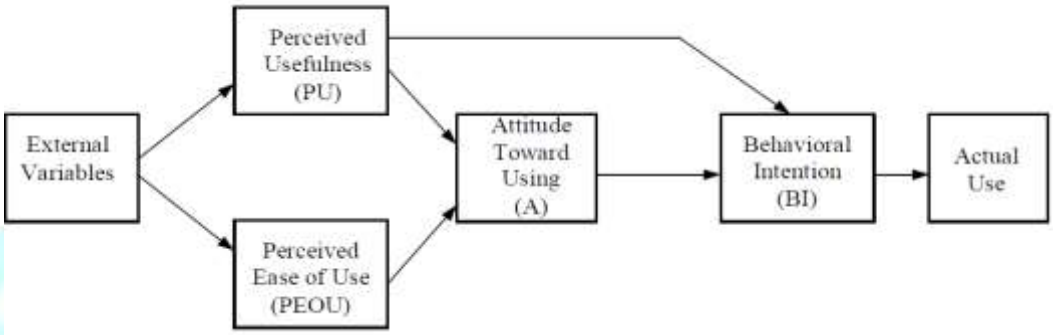

Figure 4. First modified version of Technology Acceptance Model (TAM) (Davis, Bogozzi and Warshaw, 1989).

3.5 Technology Acceptance Model

The final version of Technology Acceptance Model was formed by Venkatesh and Davis (1996) as shown in Figure 5. The main finding is both perceived usefulness and perceived ease of use were found to have a direct influence on behavior intention, thus the need for the attitude construct is eliminated here. Thus the simplified version of the TAM is obtained.[7]

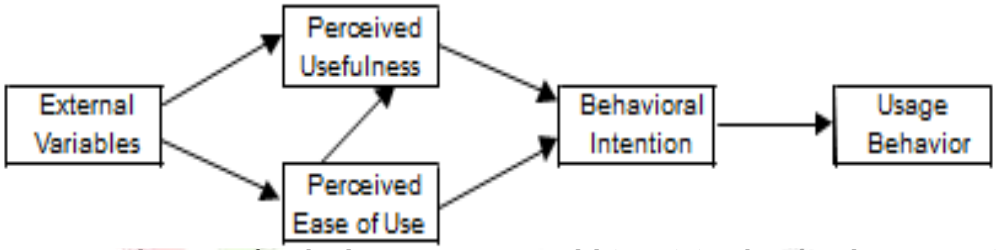

Figure 5. Final version of Technology Acceptance Model (TAM) (Venkatesh and Davis, 1996).

3.6 Technology Acceptance Model-2

This model introduces few more constructs. The affect of various factors on the Intention to Adopt things is discussed here. The external variable in the model involves both social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use).

TAM2 theorizes that users' mental assessment of the match between important goals at work and the consequences of performing job tasks using the system serves as a basis for forming perceptions regarding the usefulness of the system (Venkatesh and Davis, 2000). The results revealed that TAM 2 performed well in both voluntary and mandatory environment.. [8]

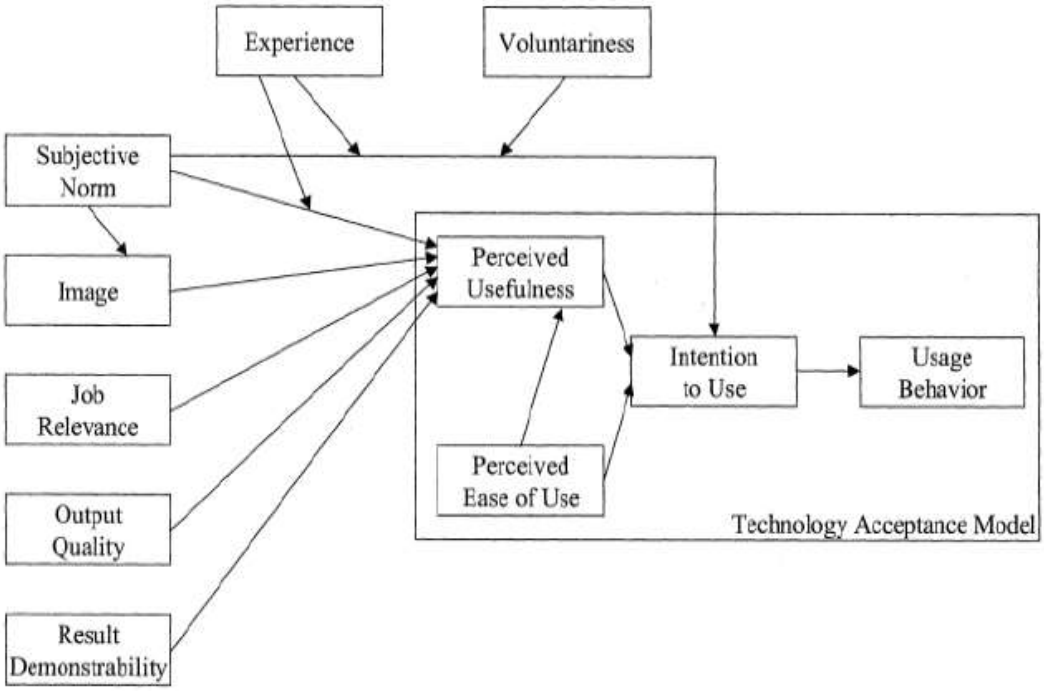

Figure 6. Technology Acceptance Model (TAM 2) (Venkatesh and Davis, 2000).

3.7 Unified Theory of Acceptance and Use of Technology (UTAUT)

Unified Theory of Acceptance and Use of Technology (UTAUT) Venkatesh, Morris, Davis and Davis (2003) studied from the previous models/theories and formed Unified Theory of Acceptance and Use of Technology (UTAUT) shown in Figure 7. The model contains four core variables: performance expectancy, effort expectancy, social influence, and facilitating conditions, and four moderating variables: gender, age, experience, and voluntariness of use. Also it posits three direct determinants of intention to use (performance expectancy, effort expectancy, and social influence) and two direct determinants of usage behavior (intention and facilitating conditions). [9]

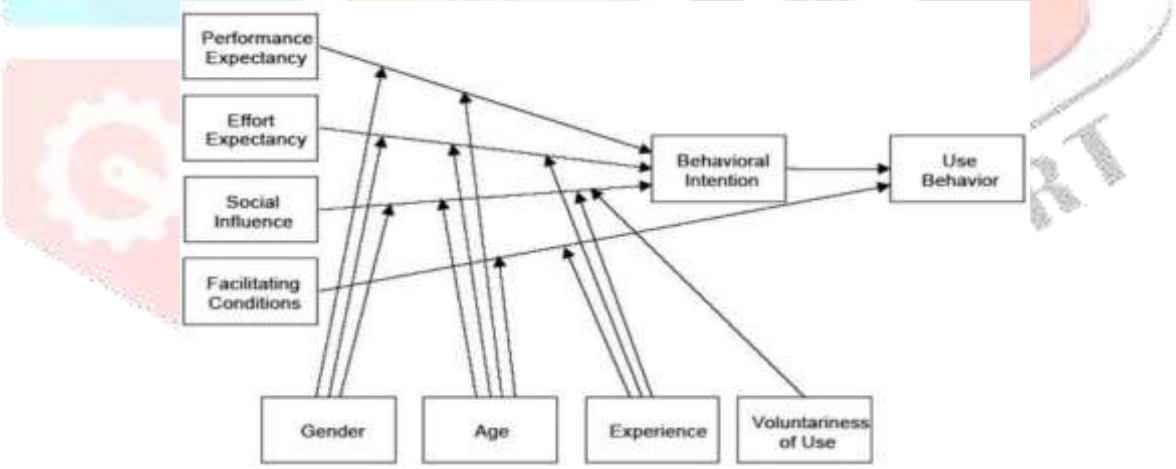

Figure 7. Unified Theory of Acceptance and Use of Technology (UTAUT)

3.8 Comparing the Models:

With more than 700 citations to his original proposal for TAM, Davis' research (Davis, 1989) has been adapted and extended in many ways.[10]

Every model is telling the success story of specific application area. The specialty of individual model is the constructs [11]and variables it comprises of. The researchers have studied the individual model in detail and its application too. Based on the factors gathered the following table (Table 1) is constructed. This table is helpful for the researchers to understand and compare the constructs and variables available in various models. Based on the requirement in specific application area, the constructs and variables can be handpicked and a conceptual framework can be constructed. [12]

Model	Constructs	Variables
TRA	Beliefs & Evaluations, Normative Belief, Attitude, Subjective Norm, Behavioural Intention, Actual Behaviour	--------
TPB	Attitude, Subjective Norm, Perceived Behavioural Control, Intention, Behaviour	--------
Original - TAM	Perceived Usefulness, Perceived Ease Of Use, Attitude Toward Using, Actual Use	X1,X2,X3
Modified - TAM	Perceived Usefulness, Perceived Ease Of Use, Attitude Toward Using, Behavioural Intention, Actual Use	External Variables
Final - TAM	Perceived Usefulness, Perceived Ease Of Use, Behavioural Intention, Usage Behaviour	External Variables
TAM-2	Perceived Usefulness, Perceived Ease Of Use, Intention to Use, Usage Behaviour,	Subjective Norm, Image, Job Relevance, Quality Output, Result Demonstrability, Experience, Voluntariness.
UTAUT	Behavioural Intention, Use Behaviour	(Core variables) Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating conditions (Moderating variables) Gender, Age, Experience, and Voluntariness of use.

Table 1 – Constructs and Variables of 7 technology Acceptance Models.

3. 9 Domain Model:

Internet of Things - IoT represents the convergence of heterogeneous technologies pertaining to different domains. Having a domain model is helpful in design of concrete IoT system architectures, as it provides a template and thus structures the analysis of specific use cases. [13]

More than just integrating a few devices within the four walls of a company ("Intranet of Things"), but require a technology that enables the cooperation and interoperability between different stakeholders, potentially involved in very different application fields. Thus defining a domain model is the important step in this direction. The main purpose of a domain model is to generate a common understanding of the domain in question. One of the main goals of the domain model development project is to develop an Architectural Reference Model (ARM) for the IoT, In addition to the domain model; the full Reference Model (part of the ARM) also includes information, communication, functional and security/privacy/trust models.

The five core concepts in the domain of the IoT are Augmented Entity (AE), User, Device, Resource, Service. The Purpose of the Domain Model is to identify the Users of the system, the involved Physical Entiry and related Virtual Entity, the Resources, Map Resources to Device types.

3.10 IOT ARM: Architectural Reference Model

For successful implementation of Internet of Things, one should understand its organization and architecture [14]. IOT architecture consists of different layers of technologies supporting IOT. It serves to illustrate how various technologies relate to each other and to communicate the scalability, modularity and configuration of IOT deployments in different scenarios. Common Layers of ARM

A. Smart device / sensor layer
B. Gateways and Networks
C. Management Service Layer
D. Application Layer

IoT ARM covers the Functional view, Future technological developments, Interoperability and Future challanges.

IV METHODOLOGY

Research Methodology (Procedure to be adopted).

The research involves various phases, which has to be followed systematically for successful completion of the process.

Research Design:

First and foremost, the area to be identified where the adoption is needed then the information about the type of population to be collected. The most important thing is introducing / training the population about the new technology. This can be achieved to a video on particular concept. For better result, the diversity in respondents experience, designation to be considered.

Data Collection:

Survey method enables for the gathering of primary data for exploratory analysis.

The TAM variables to be measured using the scales validated by Davis.

Research Instrument:

The researcher has to develop a questionnaire using the constructs available in TAM model. The selection of the items in each construct to be done based on the area of research. The literature review helps in selection of these items. The field survey approach can be followed if the population size is more. These items can be deliberated on a 7 point Likert scale.

Distribution and Collection:

To distribute the research instrument, either online /offline or paper based approach can be followed. It should be decided based on the conditions and the type of subjects. For online, the providers such as Google form,Questbank, Typeform can be used.

Sample Design and Pilot Survey:

Based on the population and application sector as well as based on the location, the design has to be done. To validate, get early feedback the researcher has to conduct the pilot survey. Based on the feedback, the research instrument can be fine-tuned for final application.

Sample Size:

Post distribution of questionnaire a particular time frame to be set to receive the responses. The received responses to be scrutinized and valid responses to be accepted. If low response rate is found for online, then paper based survey to be given importance.

Data Analysis and Result:

The collected data to be analyzed and reliability must be measured using Alpha coefficients for the constructs to verify the hypothesis and advanced statistical technique structural equation modeling to be applied for the primary responses which is collected through survey method the co variances correlations shared variance of constants to be checked the model fit in dices to be done to analyze goodness of fit of a proposed model the internal consistency of the constructor be checked a correlation Matrix and exploratory factor analysis to be done to examine the validity of the survey instrument testing once acceptable measurement model is established and evaluation of structural model Should be carried out SCM analysis provides standardized path coefficients the corresponding value to be summarized.

V CONCLUSION

The main objective of the paper was to understand various technology acceptance models. This is successfully achieved here. The various models are found during the literature review. Based on the IoT application requirement researcher has considered the seven models. The constructs and variables of these models are discussed here in detail and a consolidated table is also constructed for bird-view of these. The various application areas of IoT are listed and the basics of IoT ARM and Domain model too discussed. To adopt IoT the technology's acceptance to be studied. This needs a detailed scientific procedure. The researcher has covered this part in detail so that every layman can understand the procedure.

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