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# Contribution of Trust Factor Towards IOT Diffusion – An Empirical Study Using Acceptance Model

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**Abstract.** The Internet of Things (IoT) continues to evolve amongst the recent technologies which has a huge growth potential in terms of deployments and usage. The revenues on IoT is already nearing three trillion US dollars by 2020 despite COVID turbulences and the peak scale is expected to be touched by 2022. Literature says there would be 50 billion+ devices consuming 2 Zettabytes of data bandwidth. While more research is ongoing on the technical coverage of IoT and its features, less attention is paid to the behavioral aspects about the perception and usage of the IoT services. This paper makes an empirical study towards the influence of Trust on the acceptance of IoT and the adoption of IoT Services, with an update on UTAUT model. With the survey from 100+ IoT users applied with SEM reveals the significance on the Trust on IoT Provider.

**Keywords:** IOT, TAM, UTAUT, COVID, SEM, TRUST

## 1 Introduction

Recent years and the prevailing COVID pandemic witnesses' breakthrough on the usage of IoT enabled devices and services. The roleplay of Trust on IoT services is significant as in the cases like mobile banking services [1]. As per the industry analyst source IDC, the installed base of IoT will increase to 212 billion+ devices approximately by this year, that includes up to 30 billion+ connected devices. IDC sees the growth is driven by the large amount of intelligent systems that are going to get installed and the data collections across consumer applications, Government Agencies and the Enterprise applications [2]. These types of applications can involve the electric vehicle and the smart house, in which appliances and services that provide notifications, security, energy saving, automation, telecommunications, computers and entertainment will be integrated into a single eco system with a shared user interface. Large investments are made across the globe, including India, towards the IoT research and implementation in various forms as smart projects [3]

While there are plenty of research on the technical evolution of IoT and its Services, very less study is done on the behavioral aspects including perception and usage of IoT

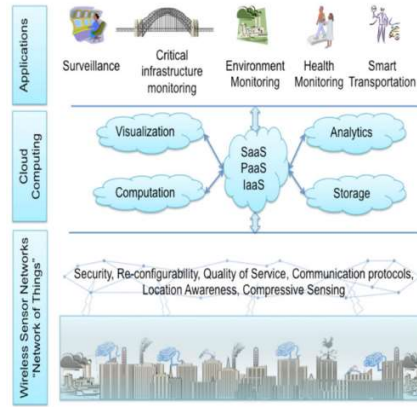
Services. Past studies have used TAM model towards assessing the perception of users for the acceptance and adoption [4]. The UTAUT model is relatively better than TAM and other theoretical models and not that much deployed effectively [5]. This paper adopts a model based on UTAUT, arrive a prototype, and validate it using survey questionnaire and feedback multiple respondents.

## 2 Literature Review

Although IoT is relatively new technology in this decade, let's review the literature part of what IoT technology covers, its segments of architecture layers and the prevailing demand on the adoption of IoT. As this paper aims to make a behavioral study, let's use the Acceptance Models that are widely used, TAM and UTAUT.

### 2.1 IoT Technology

IoT infrastructure is segmented into 4 layers namely, Sensing, Communication, Management and Application layers. The vision of IoT is perceived in 2 ways—'Thing' centric and 'Internet' centric. Internet services are focus in the Internet centric architecture. The center stage is captured by the smart objects in the object centric architecture [6] [7]. A conceptual framework of integrating the applications and ubiquitous sensing devices are shown in Fig. 1.

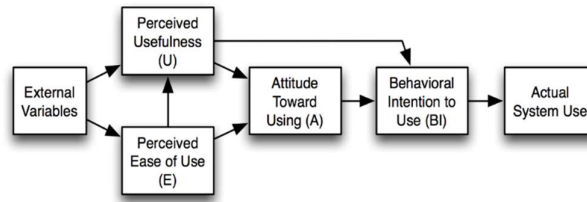


**Fig.1** IoT infrastructure from different layers

In order to get the real computation power of ubiquitous sensing and cloud, its clubbed in this framework to work together and reap the power of both frameworks. The sensor firms were invited to join the networking layer and provide their services towards the tuning of the software to become more effective. The AI part is achieved by the mining techniques available in market, which uses existing tools to manipulate the data which has been collected.

## 2.2 TAM

There are quite some theoretical models that are proposed to understand the factors that has a potential influence towards the acceptance of information technologies [8][9]. In these studies, TAM is very key model that gets into the behavior towards the adoption of Information Technology. Goal of TAM is towards discovering the influence caused by external variables on the internal beliefs, attitudes and intentions [10]. The conceptual model of TAM is shown in Fig.4 [11].



**Fig.4** TAM, version 1, (Davis, Bagozzi & Warshaw 1989)

As per TAM, the primary determinants of the Information Technology adoption in organizations and individuals are based on the ease of use and the usefulness. These acts as the basis for Attitude towards any system. This attitude towards a system identifies the use intention and the use behavior. Perceived ease of use means to what extent the respondent feels that using a system is not complex and will not consume mental efforts. Perceived usefulness is the extent to which the respondent feels that his or her job performance would get enhanced. [9]

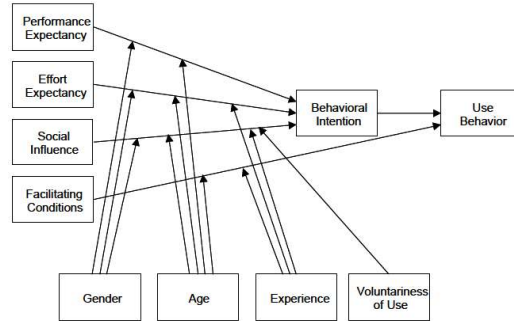
Lot of researchers were using TAM to validate the acceptance and adoption towards new technology. This mode was used by several studies including cloud computing, electronic governance, mobile learning, electronic learning.

## 2.3 Unified Theory of Acceptance and Use of Technology (UTAUT):

Plenty of theories and models exist to understand the Information Technology (IT) acceptance behavior, like TAM, Diffusion of Innovation (DOI), Theory of Planned Behavior (TPB), Theory of Reasoned Action (TRA), each focusing various factor of user's acceptance, there needs to be a model that is comprehensive one to facilitate studies on the understanding of user acceptance for any new technology.

UTAUT model proposed by Venkatesh et al [12] towards the acceptance of adoption of any new technology that integrates the findings of these earlier studies. As per this model, it includes four critical antecedents, which are Facilitating conditions, Effort expectancy, social Influence and Performance expectancy. These variables affect the behavioral intention and the actual behavior.

Gender, experience, age and voluntariness are found to moderate the above relationships. These relationships were validated by various researches including Weerakkody V et al [13] in the adoption of electronic government, Lian [14] in the adoption of cloud-based e-services and Wang [15] in the interactive decision aids for consumer adoption.



**Fig.4** UTAUT (Venkatesh et al., 2003)

Similarities from other theories and models are accommodated as part of the key variables of UTAUT. For example, the Perceived Usefulness in TAM is like the Performance Expectancy in UTAUT. Table 1 shows the core variables of UTAUT, where we see Venkatesh et al [12] has combined the previous modes of technology adoption to arrive UTAUT design.

**Table.1** The Core Variables of UTAUT

Variables	Sources
Performance Expectancy	Extrinsic Motivation (MM); Perceived Usefulness (TAM/TAM2/C-TAM-TPV) ; Relative Advantage (DOI); Job-Fit (MPCU)
Effort Expectancy	Complexity (MPCU/DOI); Perceived Easy to Use (TAM/TAM2)
Social Influence	Subjective Norm (TRA, TAM2, TPD/DTPB, C-TAM-TPD); Image (DOI); Social Factors (MPCU);
Facilitating Conditions	Facilitating Conditions (MPCU); Perceived Behavioural Control (TPB/DTPE, C-TAM-TPB); Compatibility (DOI)

Thus, we see UTAUT model is designed specifically to study and investigate the acceptance of users with respect to the new Technology Adoption. It has higher explanatory power than earlier models like TAM and suited for understanding the acceptance of IoT services [16]

### 3 Critical Review

IoT is a recent evolution and there are limited researches done in this topic, while lot of research are ongoing and expected to get more light in the coming days and months. The research to identify the factors that influences the acceptance and adoption of IoT services by consumers are ongoing in several instances.

According to Gao. L et al [17], Perceived Ease of Use, Perceived Usefulness, Perceived Behavioral Control and Perceived Enjoyment Social Influence have a significant effect on the use of IoT. This is their finding based on the research done on 368 respondents in China.

As per the research done on 2000 customers in US, by Acquity Group [18] focusing the concerns of customers to adopt IoT, the results indicated that the usefulness, awareness of the technology, security, privacy and price (cost).

With the literature study done by Evans [19] noted that lack of regulations, messaging design, slow technology adoption rate, privacy, issues with interoperability, consumer perception, data collection, cost of implementation and impactful use of big data were the barriers that affects the acceptance of IoT Services. Study done by Abu et al [20] in Malaysia Small Medium Enterprises reveals that the ease of use, attitude, usefulness are the factors that drives the adoption of technology.

The research done by Kin et al [21] with 363 students on the acceptance model for smart watches revealed that quality, perceived usefulness, appeal, cost, user attitude and intention to use were the main factors driving wearable technology.

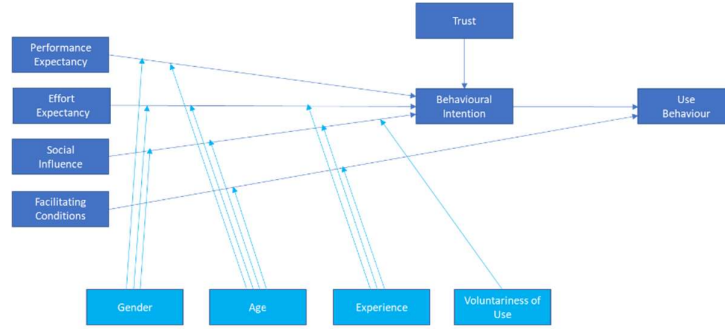
On the study done on the adoption to third party application with 269 students by Han et al [26] in US revealed that user's trust on the security applications and the technology awareness has a greater role on adoption intention. Significant observation is that, trust plays the mediator role in the security apps.

The research done by Saad T Alharbi on the Trust and Acceptance of Cloud computing [23] trust establishment was noted as one of the main barriers to adopt cloud services and applications. Hence Trust was added as a main construct that directly affects the user's behavior intention to adopt cloud services.

### 4 Theoretical Framework and Hypothesis Development

The conceptual framework is made on continuation with the study and research findings as discussed in previous sections. As most researchers have applied UTAUT model successfully for the technology adoption topics from smart watches, smart refrigerators till cloud computing, this paper also re-uses the UTAUT model. As per the research on cloud computing [24] where trust has evolved as major

construct, this research includes it as a construct on top of UTAUT model. Hence the framework of this model is revised as below.



**Fig.5** Research Model

#### 4.1 Performance Expectancy

Performance Expectancy refers to the degree to which an individual perceives that using the system will help them to attain gains in job performance [12]. This study has adapted the performance expectancy and defined as the degree to which IOT users find it useful in their lifestyle, enables to accomplish their tasks quickly, increases their chances of better life and productivity

H1: Performance Expectancy will have a positive and significant impact on Behavioral Intention to use IoT enabled products and services.

#### 4.2 Effort Expectancy

Effort Expectancy refers to the degree associated with the use of the system [12]. This study has adapted effort expectancy and referred it to the easiness of using IoT, learning to operate is easy, interaction with IoT is clear and understandable and it is easy for user to be skillful to use IoT enabled products and services.

H2: Effort Expectancy will have positive and significant impact on Behavioral Intention to use IoT enabled products and services.

#### 4.3 Social Influence

Social Influence refers to the degree to which an individual perceives how others believe that we use the system [12]. This study has adapted the social influence and referred it to the people whom influence my behavior, people I think important feels, I should use IoT. Also, my colleagues, the place of work, work administration is supporting the use of IoT enabled products and services.

H3: Social Influence will have positive and significant impact on Behavioral Intention to use IoT enabled products and services.

#### 4.4 Facilitating Conditions

Facilitating Conditions refers to the degree to which an individual believes that organizational and technical infrastructure exists to support use of the system [12]. This study has adapted the facilitating conditions and referred it the availability of necessary resources, knowledge, availability of alternate technologies for non-compatible cases and the people support to assist in the journey of IoT.

H4: Facilitating Conditions will have positive and significant impact on Use behavior

#### 4.5 Trust

Trust refers to the “willingness to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party” [24].

When the IoT concept was still new, researchers are trying to conduct qualitative studies on discovering the factors that influence to adopt this technology.

The factors that contribute to the construct Trust, as per Saad Alharbi [25] were reviewed and re-purposed as following:

**Table.2** The Factors contributing to construct Trust

Trust aspects	Related Factors
Control (C)	Level of data control
	Physical location
	Location profile
Security (S)	Encryption
	Privacy
	Auditability
Service Continuity (SC)	Service Level Agreement
	Compensation
	Backup
IoT Provider (IP)	Accreditation
	Reputation
	Policy compliance
	Transparency

Trust is evolved as an important factor in the Cloud Computing Adoption Studies done by multiple researches including Sharma et al [27]. In this research, the factors contributing to Trust on IoT Provider refers to the security, control, service continuity, reputation, policy compliance, transparency and accreditation of the IoT provider.

H5: Trust will have a positive and significant impact on Behavioral Intention to use IoT enabled products and services.



## **5 Research Methodology**

### **5.1 Variable Measurement**

The survey items used to measure IoT user's perception is adopted from literature study and expert's opinion. The survey questionnaire was developed and reviewed with 5 experts who contribute to IoT projects within Nokia. The experts feedback helped in enriching the readability of survey questions from the perspective of IoT users, to assess actual usage. The survey questionnaire used the 7-point Likert measurement scale, scaling from 1 = "strongly disagree" to 7 = "strongly agree".

### **5.2 Data Collection**

The survey questionnaire was distributed initially to 10 IoT Software Engineers as a pilot and then the following modes of data collection were used to capture survey feedback. The survey instrument is used with 60 IoT Users in paper (hard copy) format, then the networking sites using Google Forms and Amazon Mech Turk to capture the data across the globe. Due to the limited audience on IoT users, the respondent's numbers did not see a major raise and got limited to 100+ responses.

## **6 Data Analysis and Results**

Let's have a look into the findings and results, we obtain from the survey. PLS regression technique generalizes and combines features from Principle Component Analysis and multiple regressions. PLS readily handles both formative and reflective constructs [28]. PLS regression predicts or analyses a set of dependent variables; from a set of independent variables or predictors. PLS requires a minimum sample size, 10 times greater than the construct or the number of independent constructs directly impacting on dependent construct. Hence the samples size of 80 and above is a balance using PLS study [29].

### **6.1 Respondents Profile**

As IoT is new field of research, the questionnaire was distributed to the people who possess IoT knowledge. The response was captured from 100+ respondents spread across globe. After sorting the feedback with the complete ones, 83 responses were seen complete and used for further analysis.

**Table.4** Respondents Profile

Gender	Frequency	Share (%)	Education	Frequency	Share (%)	Age distribution	Frequency	Share (%)
Men	53	64	UG	52	63	20 to 30 years	77	93
Women	30	36	PG	26	31	30 to 40 years	3	4
Do not prefer to say	0	0	Other	5	6	40 to 50 years	3	4
Total	83	100	Total	83	100	Total	83	100

## 6.2 Multi Collinearity Test:

Multi collinearity is the behavior of predicting a variable using multiple regression techniques. The Variation Influence Factor (VIF) is used as a measure of multi collinearity phenomenon.  $VIF > 5$  indicates the existence of multi collinearity problem. The check on Multi collinearity is done using SmartPLS – Collinearity Statistics and following is the results.

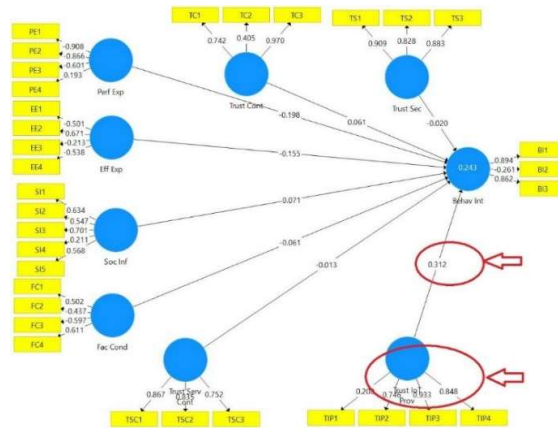
**Table.5** VIF Values.

VIF values											
PE1	1.921	TIP1	1.047	EE1	1.001	SI1	1.857	SI5	1.217	BI1	2.28
PE2	1.966	TIP2	1.652	EE2	1	SI2	1.858	TC1	1.489	BI2	1.043
PE3	1.368	TIP3	2.828	EE3	1.491	SI3	1.237	TC2	1.164	BI3	2.328
PE4	1.132	TIP4	2.335	EE4	1.492	SI4	1.077	TC3	1.538	TS1	2.959
										TSC1	1.809
										TSC2	1.448
										TSC3	1.538

Since the VIF is  $< 3$ , this data does not suffer multi collinearity problems.

## 6.3 Measurement Model Result:

To see the model fitness, the PLS Algorithm is applied and found the results as below.

**Fig.6** Measurement Model Result

The early signs indicate that Trust of IoT Provider seems to be a significant predictor of Behavioral Intention towards the adoption of IoT Services.

#### 6.4 Bootstrapping:

Bootstrapping is a non-parametric procedure that allows testing the statistical significance of PLS co-efficient. This test of bootstrapping is done on the collected data and following is the result.

**Table.8** Boot strapping results

BootStrapping output	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics ( O/STDEV )	P Values
Eff Exp -> Behav Int	-0.155	0.059	0.207	0.753	0.452
Fac Cond -> Behav Int	-0.061	-0.012	0.122	0.497	0.619
Perf Exp -> Behav Int	-0.198	0.008	0.208	0.954	0.34
Soc Inf -> Behav Int	0.071	0.072	0.129	0.553	0.58
Trust Cont -> Behav Int	0.061	0.09	0.292	0.209	0.834
Trust IoT Prov -> Behav Int	0.312	0.293	0.137	2.28	0.023
Trust Sec -> Behav Int	-0.02	-0.083	0.267	0.076	0.939
Trust Serv Cont -> Behav Int	-0.013	0.006	0.132	0.101	0.919

From this table, we see that the P-Value of Trust on IoT Provider is <0.05 and hence marks its significance.

### 7 Discussion and Implications

According to the results seen in previous sections, the Trust on IoT Provider is a significant construct that has a positive and significant impact on Behavioral Intention to use IoT enabled products and services. This variable is wisely leveraged by multiple operators in India and across the Globe, as we will see Reliance JIO being the largest mobile subscriber base in India is investing in Industry Revolution 4.0, focusing 'Make in India' strategy [30]. The second largest mobile subscriber base in India, Airtel is focusing on 'zero questions' with the focus of customer centricity [31]. These are significant steps to raise the Trust on IoT provider, evidently clear.

### 8 Acknowledgement

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### 9 Conclusion & Future Study

The research study findings indicate that the Trust on IoT Provider has a significant influence towards the Acceptance of Internet of Things Services. The study will be enhanced further to capture the findings from multiple respondents to achieve significant population. Recent researches including Yogesh Dwivedi et al [32],

Maciel M. Queiroz, Samuel Fosso Wamba et al [33] evolve in a dimension without the moderators of UTAUT as the influence is not significant in IT evolution. This is also witnessed in the recent technology adoption patterns including the accelerations caused by COVID pandemic, in many facets including, Work From Home, Online Schools, Online Shopping, e-commerce, Digitalization, accelerated 5G [34][35] deployments across the globe including competitiveness, Government prioritizations.

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