ACTUAL STATUS OF DEVELOPMENT AND APPLICATION OF INTERNET OF THINGS IN VIETNAM

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"Vietnam needs to improve legal institutions and offer favorable conditions for development of enterprises, human resources, integrated system of infrastructure, particularly information-communication technologies, development of digitally connected infrastructure, securing of network safety and security, completion of 4G mobile networks and study for implementation of 5G systems to meet demands of the Internet of Things in the shortest time" *(Chu Ngoc Anh, Minister for Science-Technology)*[2].

Abstract:

The paper introduces the basic notions of the eco system of Internet of Things (IoT) with 4 main components (hardware, software/connections, services and institutions/policies) and the eco system of the commercial IoT with two groups of actors (providers of service/application including providers of equipment, networks and platforms, and clients). Then, a global picture is drawn for development and application of IoT in Vietnam with the main actors involved into the IoT and some initial results of application of IoT in sectors of urban development, transport, agriculture and smart homes. The paper offers some recommendations for promotion of process of development and application of IoT in Vietnam.

Keywords: *Information technology, eco system of IoT; Policy; Application.*

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1. Eco system of IoT

The eco system is a new concept covering board areas and not indicating any concrete objects. The eco system can be interpreted as an "economic community on basis of interactions between organizations and individuals".

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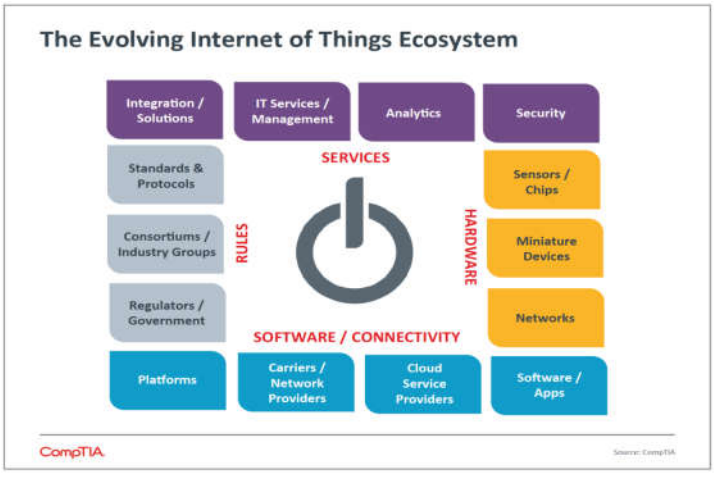
[2] Speech by Minister Chu Ngoc Anh at the signing ceremony of MoU for cooperation of establishment of "IoT Innovation Hub" between Mr. Chu Ngoc Anh, Minister for Science-Technology and Mr. Denis Brunetti – General Director, Ericsson Vietnam, Myanmar, Cambodia and Laos at the "Nobel Inspired Gala Dinner" held by Sweden Embassy in Hanoi, 28 November 2018.

This community produces products and services of values for customers and they are themselves part of this eco system.

IoT is composed from many components which create a diversified and complex model of eco system. On basis of structure of the IoT model, the IoT eco system includes the 4 main components: Policies, Software/Connections; Hardware and Services (Fig. 1) which include sections of hardware, connecting software, platform software, data analyzing tools and etc.



Source: Michele Mackenzie and Andrew Cheung, 2017

Figure 1. IoT eco system

1.1. Hardware

- Equipments of the IoT eco system include hardware components capable to interface according to the pre-defined IoT standards. These equipments are highly diversified depending on purposes of use: individual smart devices (phones, watches and etc.), home appliances (refrigerators, air conditioners and etc.) or monitoring devices and sensors for environment control (temperature, humidity, luminiosity and etc.)
- IoT connecting infrastructure is the network of infrastructure systems and mobile transmission lines for IoT equipment to be connected and to exchange data through a system of central platform software. These equipments can be connected to central software directly or through intermediate equipments (gates).

1.2 Software/Connections

- *IoT platform software*: It is the heart of the IoT eco system having functions of management of connections, synthesis and processing of

data transmitted back from equipments. The software is required to connect the things together or make data usable, and the connections are necessary for sharing information or interacting with the whole system.

- *Software for analysis of big data*: It is the component which makes the main value of the IoT eco system because the final destination of IoT, as top purpose, is not only to connect and to receive data from equipments but to exploit them to create values for end users.

1.3. Services

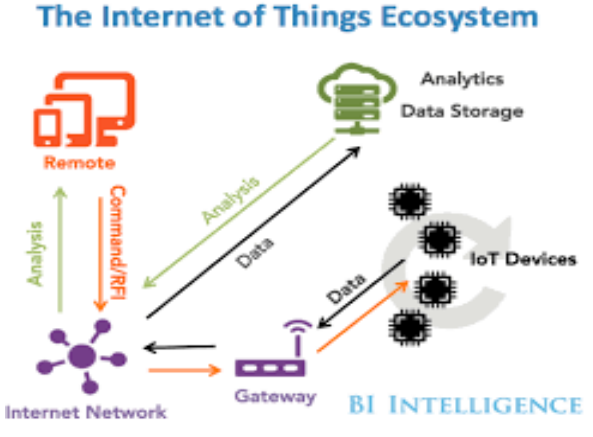
IoT services: actually IoT applications can be seen in numerous fields such as health cares, urban systems, plants, energy systems, environment, agriculture, traffic and services for end users.

1.4. Rules/Regulations

Policies: another aspect of elements deciding the development of the IoT eco system deals with standards, regulations and policies by the Government which allow the IoT eco system to develop sustainably.

In addition, the development of the IoT eco system requires many elements such as connections, transmission, management of data, confidentiality and etc. *(Comptia, 2015).*

According to recommendations by International Telecommunication Union (ITU-T.2012), the IoT eco system includes various components such as equipments, analysis tools, networks and confidentiality software. The IoT eco system includes the entities (users, enterprises and the Government) capable to connect and control their equipments in various environments such as production, transport, traffic, agriculture and etc.

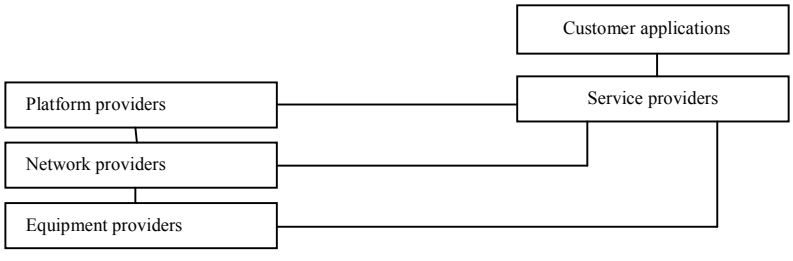


Source: IEEE.2015

Figure 2. Operational model of the IoT eco system

For operations in the IoT eco system, when an entity uses a remote control device (e.g. smart phone or Ipad) to send an order or request information through a network to an IoT equipment, the equipments carry out the order or request information and send back the information through the network for analysis and display on the remote control equipments (Fig. 2).

On basis of the IoT eco system, another concept called "the commercial IoT eco system" is proposed and set up around concrete technological solutions with a focus for certain domain of application such as the solution of identification through radio frequencies or ZigBee communication information in smart homes and retail sales systems. The commercial IoT eco system includes various providers. The roles of providers and connections in the IoT eco system are shown in Fig. 3.



Source: ITU-T.2012.

Figure 3. Commercial IoT eco system

- *Equipment providers*: Equipment providers are in charge to supply equipments which supply raw data or contents to network providers and to applications provided by services.
- *Network providers*: Network providers play central roles in the IoT eco system. Particularly, network providers carry out the following functions:
  + Access and integration of resources supplied by other providers;
  + Support and control of IoT infrastructure;
  + Supply of capabilities of IoT including resources and capabilities of the networks for other providers.
- *Platform providers*: Platform providers supply capabilities of integration and open interface. Different platforms can supply different capabilities to application providers. Platforms include capabilities of integration, storing and processing of data and management of equipments.
- *Application providers*: Application providers supply applications which use capabilities and resources supplied by network providers, equipments providers and platform providers for supply of IoT application to customers.

- *Customer applications*: Customers are users of IoT applications supplied by application providers.

IoT is considered as the next industrial revolution. It will change the ways the enterprises, the Government and users interact with the material world. IoT is a complex eco system. So the understanding of the IoT eco system as well as the connections between components of the IoT eco system will define challenges and opportunities in process of development and application of IoT for related parties such as administrators, providers and users.

2. Actual status of development of Vietnam IoT eco system

2.1. Actors of the IoT eco system

As said above, the IoT eco system includes the main actors: the Government (issuing policies and promoting development through public investments); Enterprises/Start-ups/Communities of development (supplying technological solutions for connecting hardwares and services); Markets of products and connections between these actors.

During the past times, Vietnam IoT eco system implemented actions to activate development of the IoT eco system in Vietnam, particularly the active participation of Vietnam enterprises in the four components (applications, networks, platforms and equipments) (Fig. 4).

The global picture of IoT in Vietnam shows that the segments such as building of infrastructure of connections and open platforms were implemented by large communication companies such as Viettel and VNPT. In addition, some companies such as DTT, FPT, VNG and Konexy are those software enterprises which are doing research on IoT platforms.

IoT Application	VINATEX, EVN, SAMSUNG, VinPro, THACO TRUONG HAI AUTO	**ATTT**
Network	vinaphone, mobifone, VIETTEL, Hãy nói theo cách của bạn, vietnamobile, mobile	Bkav, CMC INFOSEC, VNCS
Platforms	FPT Software, DTT TECHNOLOGY GROUP, VNPT Technology A MEMBER OF VNPT, VIETTEL, mobifone	
IoT Equipment	FPT, VNPT Technology A MEMBER OF VNPT, VIETTEL, ICDREC, cam	

Source: Research project team

Figure 4. Vietnam IoT eco system

Smaller size companies are using existing infrastructure for building systems of solutions and introduce them into markets in a short time. The Government provides supports through its roles in activities to build up a sustainable eco system including development supporting policies and set-up of technological incubators. These moves would provide enterprises with supports, particularly start-ups.

In addition, in the IoT eco system, there are compulsorily the elements such as the formation and development of high tech zones, incubators, investment foundations and etc. which play the roles of catalysts for promotion of start-ups in IoT. Universities and research institutes also play their roles in supply of human resources qualified to meet development requirements of IoT. In addition, research teams, vocational associations and teams of individuals and organizations take part in the eco system to enhance awareness of the roles of IoT in the global development trends.

2.2. Initial results of applications of IoT in Vietnam

In development process of IoT in Vietnam, the solutions in structures of sectors were studied and developed in various ways. The core features of the Vietnam context are coupled with difficulties and potentials for socio-economic development where the main focus is for urban development, traffic, agriculture, smart homes and etc. Despite of short time and restricted scale of development of IoT in Vietnam, some applications get commercialized, give contributions in actions and provide effective implementations, particularly in agriculture and traffic sectors.

Regarding the market of IoT, Vietnam is found as a “hot point” to attract research and production participations from many technological companies. Vietnam companies, however, face problems of “looking for benefits” through their visions for incubation of start-ups and/or provision of licenses for third parties. Vietnam has actually some enterprises which master technologies and provide good solutions (even comparatible to international markets such as smart phones by BKAV). Even so, the business doing of these enterprises still faces difficulties which are related to human factors such as: unfull awareness by customers for smart products or low wishes to shift from tranditional solutions to smart ones.

Some examples can be shown as illustrations for development of IoT, namely: Mimosa Tech was successful in commercialization of solutions for precision agriculture, Hachi provided solutions to build up automatically operated home gardens, BKAV and Lumi became local market leaders in smart home sectors and made exports to Australia, Singapore and India, Abivin was the first company to collect data from vehicles on basis of

digital maps then to optimize the travels for vehicles. In addition, many other applications are still in stages of test and trials; they need certain time for completion and then market commercialization.

Among implementations for extending larger the scale of IoT, majority of solutions are supplied by overseas providers. For example, in sector of precision processing of vegetable and fruit, TAP solutions (Israel vendor) were implemented in Tam Dao area, Vinh Phuc Province, and FPT made joint actions with Fujitsu for development of smart agriculture. In breeding sector, TH-True Milk imported technologies for cow feeding, VinEco imported technologies of green house cultivation of vegetable from Israel. Technologies for sugar cane cultivation and sugar refining industry were imported from Israel. Other technologies were imported for high tech cultivation of shrimp in Soc Trang Province and for cultivation of flowers in Lam Dong Province.

The se-up of IoT labs in Hoa Lac High Tech Park is the result of cooperation of Ministry of Science-Technology, Hoa Lac High Tech Park, DTT, Dell and Intel. In addition, many other IoT labs are under construction with visions to support the ideas and development of products by newly established IoT companies. Some enterprises also are building their own labs for research and development of IoT.

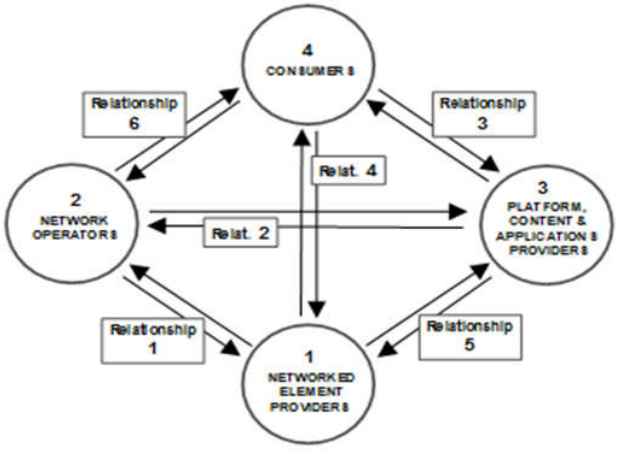
The global view shows the gradual upgrading and completion of Vietnam eco system with many IoT applications under R&D, test and small scale implementation stages. There is no common road maps, however, for all the actors to join hands for development of IoT in Vietnam.

Actually, Vietnam has no IoT applications which can produce really strong impacts to social life. In a short time, some smart applications in sector of traffic such as non-stop collection of tolls, camera record based penalties of traffic rule violations, express delivery services and services by Uber and Grab expected as IoT related applications will be largely used. Some potential sectors such as electronic medical services, smart agriculture and smart real estate need to have time to provide applications suitable for Vietnam environment.

In industrial sectors the picture is totally different where almost all the industrial systems, if using IoT based technologies, come from foreign enterprises. Local enterprises only focus attentions on applications provided on platform of mobile phones and computers without maximizing smart aspects of systems of sensors and exploitation of big data. Particularly, hardware equipments such as cameras, radio frequency based identification devices and chemical sensors have to be imported from external sources

2.3. Innovation IoT eco systems

In order to have a global view on the innovative IoT eco system in Vietnam we need to have a view on the innovative eco system of information and communication technologies proposed by Fransman *(Martin Fransman, 2014).* Fig. 5 can provide certain evaluation of capabilities and roles of the components in this eco system.



Source: Martin Fransman, 2014

Figure 5. Innovative eco system of information-communication technologies

If putting these components in consecutive order of layers we can see immediately the IT sector of Vietnam has a very low chance to enter Layer 1 (providers of components for communication infrastructure) which gets already narrowly sandwiched with great players such as Cisco, Huawei, HP, Dell and others. In this scheme, the most considerable point to note is the good position of Vietnam enterprises such as VNPT, Viettel, Mobifone and FPT in Layer 2 (operators of communication infrastructure). The focus of Vietnam would be made for Layer 3 (providers of platform, applications and contents).

For development of Layer 3 we need to make references to this model in the world and in other sectors of Vietnam. The eco system of ICT (information-communication technologies) in the world can be intepreted as follows.

The Internet introduced revolution makes a great leap for Layer 3 which produces the greatest volumes of turnovers and benefits. The leading companies in this sector made such great growing moves that allow them to start negotiations with players in Layer 2 and particularly to create options to substitute players in Layer 1. For example, Facebook, Google and Apple

conducted bidirectional negotiations with providers of network infrastructure. More than that, they were successful in creation of their own components in Layer 2, namely X-Project by Google to use air balloons for provision of Internet services as well as the project of provision of free Internet service by Facebook. The leading companies in Layer 3 give the re-definition of standards of Layer 1 and offer open markets for open technologies with better prices and more creativity. It is, in fact, the case of the open sources of software platform middleware (Cloud computing systems) or Hadoop platform of big data by Google, and the open source hardware by Facebook.

Notes:
Top Layer: Final Consumer
Layer 3: World trade
Layer 2 and 3: Finance market
Layer 2: Rules
Layer 1: World trade and Standardization

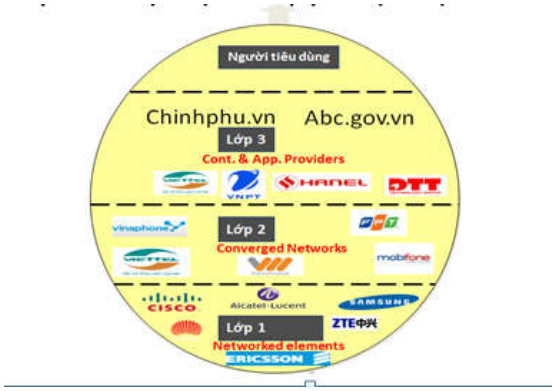
Figure 6. Outputs of creative products and services (from the three Layers)

The changes in Layer 3 lead to strong changes in Layer 1. It is the cases where IBM had sold the division of personal computers and HP is found in position to do the same now. In addition to that, these moves offer opportunities to other companies which did only fabricating works, such was the case where China and India companies sell now directly their products to Facebook and Google without needs to pay trademark fees for goods as they used to do before.

In Vietnam these changes are occurring but not observed in global scales. In a small scale, the changes are made in the E-Government sector. In this model Vietnam masters Layer 2 and Layer 3 and therefore starts strong development in the E-Government sector. The E-Government model of Da Nang City has been built up from open source platforms developed by 7 local companies under South Korean consulting supports. The success of the project is worth to be noted. The Prime Minister decided to extend the model to the provinces and cities as well as economic sectors of the country. The community of Open E-Government Platform (OEP) gets established and involves local, large and well reputed, companies such as VNPT, Hanel, DDT and others as well as some companies from the region. The OEP, even implemented in some localities and sectors, offers a kick-off for new waves

of serious investments by other enterprises for development of E-Government technologies including development of software for that[1]. That is the evidence for establishment of the innovative eco system in E-Government where the three actors: users, administration and population get more benefits. The development of E-Government offers chances for export activities by Vietnam companies, namely FPT won a USD30 million deal in Bangladesh, Viettel sets a plan for implementation in Africa or Hanel DDT develops a project in Myanmar *(Nguyen The Trung, 2015)*.

Eco system for development of E-Government in Vietnam



Source: Nguyen The Trung, 2015.

Figure 7. E-Government products and services

The most aspect to be improved actually is the lack of start-ups which are in fact the largest source of creativity. With the expected suitable policies by the Government in the next short time, a boom of creative activities by start-ups is totally possible to produce applications which fit needs of population and enterprises. E-Government would be more effective by multiple times with new applications in mobile phones where users need to have these gadgets for access, simple operations and follow-up of public services and interaction with governments. Data, once getting shared (in open data models), will be used creatively by start-ups for creation of new applications for traffic jams, degraded infrastructure, social security problems and etc. where the population can get connected immediately with authorities in charges. In case the Government does not yet create these mechanisms, start-ups need to wait until enterprises in Layer 3 develop the platforms for access, integration and use of data in fast ways. That, of course, depends on friendly wills and capabilities of enterprises in Layer 3.

[1] https://www.youtube.com/watch?v=htYYt3yWa2E

The problem now is when only because the eco system had been set up. Experiences made from the above analysis show that the actors in Layer 3 play the deciding roles in development of the innovative eco system in Vietnam *(Nguyen The Trung, 2015)*.

In Vietnam, it is already the time suitable for discussion about the participation in chains of values of IoT since IoT is now in initial stages of development and not fully formed yet, particularly in terms of standards of connections and confidentiality requirements. Also, the IoT equipments for Vietnam market remain still in low level, not enough to attract international companies for provision of overall solutions.

Therefore, the chances for Vietnam companies to take part in chains of values remain very large. This, however, requires the involvement of all the actors because IoT solutions are not only standard hardware and software but also specific ones for certain sectors. It offers chances for enterprises in various sectors in Vietnam to join hands for production of useful applications. Agriculture is a strategic and highly competitive sector where Vietnam enterprises can mobilize advantageous potentials for development of IoT. Also, the management of natural disasters and climate change adaptations is an attractive sector for IoT. Vietnam is capable to produce fully local equipments as the case where Mimosa fabricates moisture and temperature sensors for agricultural use or DTT fabricates TUHOC STEM sets for educational use. The next stage can be the fabrication of more complex equipments such as the devices for radio frequency based identification developed by Center for Research-Training-Design of Microchips or the most advanced and smartest IP cameras. This background lets us believe that the IoT industries in Vietnam have chances and opportunities for development.

3. Conclusions

As it was shown there is no common standards for definitions of IoT as well as standard architecture models for IoT. IoT includes basic layers: Equipment Layer, Network Layer, Service Support Layer and Application Layer.

Problems related to development of IoT cover a very broad scope which is not confined within any technical area of ICT but expands over all the sectors including hardware, software, communication connections, network administration and database management. In addition the development of IoT relates to technical and technological areas in other sectors such as automated control, precision engineering, environment technologies, agriculture and other industrial sectors. Therefore, the realization of

objectives of IoT requires cooperation of research and development activities in different fileds to settle the rised problems which could lead to creation of global and complete platforms and application of IoT based services.

Some countries in the region had set up the national R&D system for IoT. China, for example does it as the result of the 13-th 5 year socio-economic development plan, 2016-2020 period. The system includes various enterprises such as service of hub communication and distribution of system development of IoT. Universities and research institutes make focus of research of key technologies while standard organizations are in charge for setting up of standards for IoT over the whole country. Up to now, the IoT based industries were developed and located mainly in coastal regions such as Bohai Bay, Yangtze Delta, Pearl River and some localities in Central and West regions of China *(Shanzhi, Chen et al., 2014; Bach Tan Sinh, Duong Khanh Duong, Dang Thi Hoa, 2018).* Vietnam can make references to the case of China to build up a national R&D system for development of IoT.

Learning the chain of values is an important part in development of IoT which defines well the ways the services are provided. IoT has a very complex chain of values since, in practice, it make impacts to a huge number of procedures. Larger chances mean the involvement of more parties which need to cooperate each with other for provision of services on platforms of IoT. The learning of the chain of values would help plans of development of IoT to be right guided for admin managers, enterprises and particularly start-ups in IoT.

The IoT eco system offers policy based tools to support development of IoT. For right development and large application of IoT in various sectors, some policy based solutions should be implemented, namely: (i) Enhancement of awareness by organizations in all levels, enterprises and population on the role of IoT and its impacts to socio-economic development; (ii) Building of national strategies for development and application of IoT in short, middle and long terms of visions; and (iii) Formation of innovative eco system and start-ups in IoT where the focus should be put on the role of the State in offering a supporting environment and positive economic impacts from IoT based industries in socio-economic sectors, in building the 5G technology based infrastructure of communication networks, unifying IoT standards and enhancing confidentiality, safety and security measures for IoT.

Today, the strong development of advanced technologies such as artificial intelligence (AI), big data, 3D printing and others are under way to form a

new platform for development. With the above notes technologies as cores, the 4-th industrial revolution is expecting to make radical changes in socio-economic activities including the modes of production, trade, transport and even the modes the human kind lives and entertains. In process of development and application, the above noted technologies, even different in their nature, have toughly interbinding connections. A separated development and application of a single technology would be difficult to bring in large effectiveness or socio-economic benefits. Therefore the next study of development policies in Vietnam should balance multi-directional and mutual impacts between the actors in this platform of IoT. IoT is the senses, Big Data is the fuel, and artificial Intelligence is the brain to realize the future of a smart connected world./.

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