Adjusting ICT Capacity Planning by Minimizing Cyber Crime Effects in Urban Area: A System Dynamics Approach

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***Abstract*— In ICT capacity planning process, many organizations or institutions ignore unconsciously other components except statistical data of bandwidth utilization of ICT products. On this occasion, the ICT capacity planning process is analyzed by using system dynamics that considers some factors or components which are combinations between technical and non technical aspects such as: business, education, ICT infrastructure, ICT usage and cyber crime. Simulation of interrelationship between the components is conducted to understand the behavior of the system. System dynamics gives us input on correction of the statistical data by minimizing cyber crime effects. In this paper, it is also introduced the System Breakdown Structure (SBS), a technique to breakdown a big and complex system into smaller and manageable components. The objective of this SBS is to make system dynamics more expandable in hierarchy way in analyzing a system.**

Keywords—system dynamics; ICT; capacity planning

I. Introduction

ICT has become a major requirement in urban areas whether to do some fun activities, such as in online games, social media, chatting and communication or to do more serious or work related activities, such as in business ERP application, collaboration and communication which confidentiality, integrity, availability (CIA) of the data are more important [1],[2]. Application such as email system, news and social media is a necessity for urban people [3].

Business without ICT will lose its ability to win competition [4]. Business sector is dependent a lot on ICT because it adds more values and leads to financial benefits. Nowadays, ICT has evolved into a tool not only to add values to the business activities, but also to generate new business activities to contribute more revenues to the company [5].

A significant growth of business generates a demand for a better ICT infrastructure. ICT infrastructure consists of network, storage, server, and data center infrastructures [6], [7], [8]. Without a good ICT infrastructure, some people are reluctant to use the e-business application in the internet. A poor performance of connection is a major reason for them not to use ICT in some regions. To have a good performance, at least the ICT infrastructure needs to maintain 50% availability of its capacity for spike usage. It becomes the buffer for any unusual activities. Some applications are time sensitive, and need very fast response. This buffer is able to overcome those problems.

The ICT technology evolves dynamically to become more complex and needs more special skill sets [9], [10]. It creates more demands in education sector to support the requirements. Unfortunately, education sector is not fast enough to follow the growth of business sector.

Education positively contributes cyber crime awareness to people [11], [12]. This awareness is to overcome cyber crime effects, the negative impacts of ICT growth. Some people are still reluctant to use ICT, especially for business transactions, because of the cyber crime. The appropriate education increases the people's awareness to do the right way of business transactions via internet. The right education with ethics and laws in ICT makes people more responsible to their activities. It reduces the cyber crime in the society. In the end, this decreases the illegal activities and the resistance to use ICT.

These positive and negative components influence how people use ICT. The phenomenon of ICT usage occurs as the up and down process, in accordance with the components that support and hinder it. To get the optimal result, it depends on how good we are to minimize the negative impact and maximize the positive impact. In our case, the adjustment will be done by minimizing the cyber crime effects to achieve optimal outcome of ICT Infrastructure.

At the time that the demand of ICT increases continuously, it makes the ICT to become more critical. ICT inevitably becomes a necessity, no longer just a tool. Without ICT, the undertaken process is disrupted. Disruption may be caused by the equipment failure or the incompetence in planning and predicting the future usage. In this paper, it is discussed more about ICT usage in the future. How ICT capacity planning is able to support the growth of economic and business [13].

ICT capacity planning is needed to maintain sustainability and continuation of business. By using right methodology, a good ICT Infrastructure can provide people with more reliable services. Business sector, education sector and others will continue to grow positively. ICT Infrastructure at least will not hinder the growth of these sectors. On the contrary, if the process of ICT capacity planning is not conducted properly, business opportunities will be lost [13], [14].

What will happen if ICT infrastructure is not able to follow the growth of business? Definitely, people will lose opportunities, especially in business sector. The government will lose opportunities to increase competitiveness and also prosperity of the nation.

In this perspective, even if the ICT infrastructure is provided by private company, government is still responsible to influence them through supportive regulations. The appropriate plan on this ICT Infrastructure increases national or regional competitive advantage [15].

Many capacity planning processes are done in static way, by assuming that current conditions will not be changed. Capacity planning by analyzing the statistical data of production conducted in the past and predicting future demand is not enough. The level of demand is not only measured by the production of statistical data, but also behavior of the existing system. Components of the system affect and influence each other. It is dynamic, not static. Adjustment or intervention in certain components can be done to achieve a better outcome [16].

In the system dynamics, components were studied dynamically to obtain optimal output and behavior of system by simulating few different scenarios. This is explained well by Jay Forrester [17], [18], [19], John Sterman [16], Peter Senge [20] and other experts in system dynamics. Capacity planning with system dynamics approach is to optimize the capacity planning process and to identify the dynamic behavior as the correction of the statistical data.

II. Cyber Crime Effects in ICT and Economic Growth Correlation

It has become evident to us that ICT and economic growth have a positive correlation [4], [21], [22]. A good ICT infrastructure provides economic opportunities for the users to obtain information, business opportunities and others. Both of them have mutually reinforcing relationship [16]. If number of ICT users increase, they will increase the ICT usage and subsequently increase economic growth. And vice versa, if economic growth increases, it will increase the utilization of ICT and the number of ICT users.

It is the key of success to utilize ICT optimally for economic growth. If so, then ICT will grow along with economic development, but keep in mind about the factors inhibiting it. Increased utilization of ICT is not big enough to provide adequate benefits if you have big negative effects anyway. Concrete example is utilization of ICT in the business world, such as e-commerce, which transactions are made online using credit card. It is a common thing in developed countries which established laws and regulations are in place. But in some countries, it is still a horrible thing because of the risk of existing cyber crime.

Bad person is motivated to do illegal activities or cyber crime if the performance of ICT infrastructure and the utilization of ICT usage increase. On the contrary, cyber crime impacts negatively to ICT usage and subsequently to ICT infrastructure. It is called as balancing loop relationship [16].

The inability to provide a better ICT infrastructure to support ICT usage is the main negative thing which could inhabit the economic growth. ITU (Information Technology Union) has a big concern on this, and they come with the indicator that they called it as Digital Access Index (DAI), and now transformed into IDI (ICT Development Index) [23]. If the negative effects are overcome, it will accelerate the absorption and utilization of ICT.

III. System Dynamics Approach

System dynamics which was first introduced by Jay Forrester [17] has been growing and providing a new perspective for analyzing phenomena, such as in economical, political, social and cultural aspects. On this occasion, author will attempt to use this approach to identify the correction on statistically ICT capacity planning after minimizing components of cyber crime effects. The statistically data of the ICT usage without system dynamics approach can be used as the baseline for the model. By simulating interrelationship between components on business, ICT infrastructure, ICT usage, education and cyber crime, the parameters of components are identified.

It is called as the ideal model, if it is able to simulate the real system. The result of ideal model is the same as the result that will be happened in the real system. For some cases, it is very hard to identify the correct components and parameters to match the real system. In practice, it is suggested to focus on the certain area we need to study [16].

In our case, the model is represented by five big components. The interrelation between components and the behavior of each component (see Fig. 1) are determined. The next step is to minimize the cyber crime effects to find the correction.

A. *Integrating System Components*

It is hard to find a model with high similarity to the real system. In this research, ICT system is only focus to the five components which are business, education, ICT infrastructure, ICT usage and cyber crime. Business and education component create the reinforcing or positive loops together with ICT usage and ICT infrastructure components [16]. On the contrary, cyber crime component is a barrier for ICT Infrastructure and ICT usage component to continue growing. Of course, it will also inhibit indirectly the development of others such as business and education components.

Furthermore, the components of the system are still big enough for analysis. It is much easier if these components are broken down into smaller components. Author calls this technique as System Breakdown Structure (SBS). These components will be marked by numbering in the System Dynamics Diagram View (SDDV). This numbering looks simple but it will be useful when analyzing a complex systems.

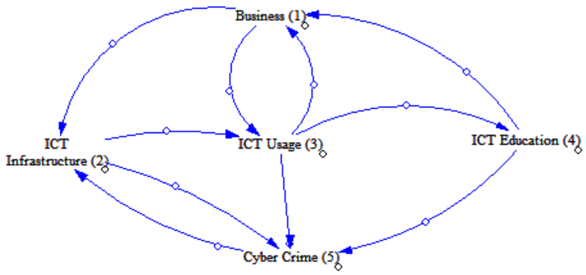

Fig. 1. System Dynamics Diagram View (before the breakdown).

After expanding Fig. 1, by using system breakdown structure, it becomes Fig. 2. ICT usage (3.1) stimulates some new business opportunities. The higher the ICT usage (3.1) is utilized, the higher business activity (1.2) increases. Likewise, ICT education (4.1) produces skilled manpower to sustain growth of business activities (1.2).

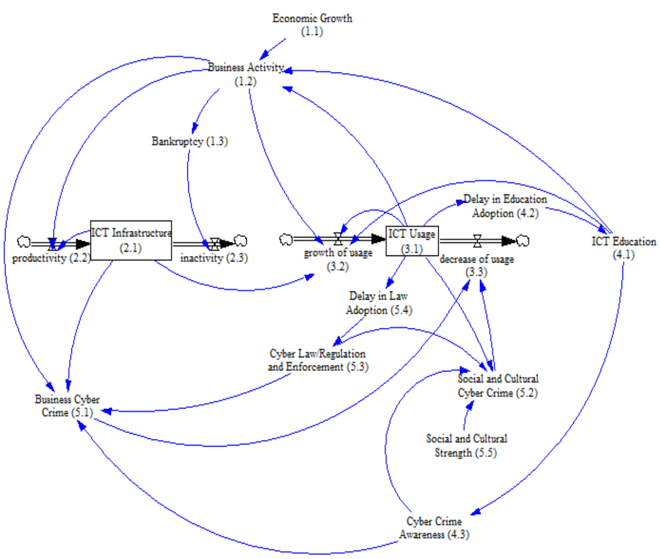

Fig. 2. Expanded System Dynamics Diagram View.

The business activity (1.2) does not always impact positively to other components. It impacts negatively by increasing business cyber crime (5.1). Even more if it is supported by good ICT infrastructure (2.1), the bad person will use it easily with wrong intention. Another negative impact, social and cultural cyber crime (5.5) continues increasing if ICT usage (3.1) increases. The bad person could put some internet contents which impact negatively to the society. Unlike business cyber crime, it does not impact directly on financial aspects. Improvements in the field of cyber law / regulation and enforcement (5.3); and cyber crime awareness (4.3) are very helpful in fight against cyber crime.

In this research, few scenarios are created with and without adjustment of certain parameters. By reducing the delay of ICT education adoption (4.2) and the delay of law adoption (5.4), it will minimize cyber crime effects. The result will inform us the correction on the statistically data of ICT capacity planning process. It is to support more demands of the ICT usage in the future if the intervention, minimizing cyber crime effects, is implemented.

B. Running the Simulation and Analysis

From the results of the previous section, configuring simulation software is conducted. The software is Vensim PLE for Windows v6.2 from Ventana System, Inc. Based on the SDDV (see Fig. 1), a Structured View Table (SVT) is created.

TABLE I. STRUCTURE VIEW TABLE (SVT) OF FIG. 1

No.	Description	Equation	Type	Value	Unit
1.	Business	(3) + (4)			
2.	ICT Infrastructure	(1) – (5)			
3.	ICT Usage	(1) + (2)			
4.	ICT Education	(3)			
5.	Cyber Crime	(3) + (4)			

Each item in description column is actually the component of the system. The number of the item is the same as the component number on the SDDV (see Fig. 1). The number is used to create equation or algorithm which explains the relationship between components. Such as:

$$\text{Business} = \text{ICT Usage} + \text{ICT Education} \quad (1)$$

If you see the SDDV (see Fig. 1), the “Business” component receive two inputs from “ICT Usage” and “ICT Education” component. “Business” is represented by number (1), “ICT usage” is (3) and “ICT education” is (4). And to make it easy and simple, it can be rewritten as:

$$(1) = (3) + (4) \quad (2)$$

This is shown in equation column in table above as “(3) + (4)”. The business which is represented by (1) is in the description column. The rest of columns are for type of the equation or algorithm, certain value that author need to indicate to and unit of data or information. At this moment, it is not necessary to fill in those columns.

Next, after applying the SBS (see Fig. 2), the more detail Structured View Table (SVT) is created as in Table 2. In this table, some assumptions are created. Economic growth (1.1) value is a constant, six. This number is to show that the economic from other sectors has supported well into our system. Every 200 gigabytes per month of ICT usage (3.1) will generate one point of business activity (1.2). The activities could be setting up a new company, creating a project or others. Not all businesses are running well, it is assumed that 1% of business activity (1.2) will go to bankruptcy (1.3) or failure. Initial value of ICT infrastructure (2.1) is 100 gigabytes per month. An hundred points of business activity (1.2) will create growth 40 gigabytes per month on ICT infrastructure

(2.1) and ICT usage (3.1). It means one point of business activity (1.2) utilizes 0.4 gigabyte per month of traffic. Cyber crime effects (5.1) and (5.2) will make some people reluctant to use internet in their activities. One point increases of cyber crime effects (5.1) and (5.2), this will decrease 0.4 gigabyte per month of ICT usage (3.1). An hundred points of business activity will create one point of business cyber crime (5.1). An hundred gigabytes per month of ICT infrastructure (2.1) will create one point of business cyber crime (5.1). The better ICT infrastructure (2.1) is developed, the more convenient bad person does their illegal activities. The ideal ICT usage (3.1) is not more than 50% of ICT infrastructure (2.1). If the ICT usage (3.1) is more than 50% ICT infrastructure (2.1), it is assumed that performance degradation is started. This slows down the growth of ICT usage (3.1). In this condition, it is assumed that the increase is only 25%. An hundred gigabytes per month of ICT usage (3.1) will generate one point of cyber law / regulation and enforcement (5.3); and one point of social and cultural cyber crime (5.2). Social and cultural strength (5.5) value is seven. It is assumed that the urban people still has a good social and cultural strength (5.5).

TABLE II. STRUCTURE VIEW TABLE (SVT) OF FIG. 2

No.	Description	Equation	Type	Value	Unit
1	**Business**				
1.1	Economic Growth	6	Cons		Point
1.2	Business Activity	(1.1)+(4.1)+(3.1)/200			Point
1.3	Bankruptcy	(1.2)/100			Point
2	**ICT Infrastructure**				
2.1	ICT Infrastructure	(2.2) – (2.3)	Level	Init = 100	gigabytes per month
2.2	Productivity	(1.2) * 0.4			(2.1) per month
2.3	Inactivity	(1.3)			– (2.1) per month
3	**ICT Usage**				
3.1	ICT Usage	(3.2) – (3.3)	Level	Init = 80	gigabytes per month
3.2	growth of usage (Normal)	(1.2)*0.4 +(4.1)*0.4		Max = (2.1) *0.5	(3.1) per month
	growth of usage (Condition)	(1.2)*0.1 +(4.1)*0.1		if (3.1) > (2.1) *0.5	(3.1) per month
3.3	decrease of usage	(5.1)*0.4 +(5.2)*0.4			– (3.1) per month
4.	**ICT Education**				
4.1	ICT Education	(4.2)/100			Point
4.2	Delay in Education Adoption	Delay (3.1), 24 month	Delay		Point
4.3	Cyber Crime Awareness	(4.1)			Point
5.	**Cyber Crime**				
5.1	Business Cyber Crime	(1.2)/100 +(2.1)/100– (4.3) – (5.3)		Min = 0	Point
5.2	Social and Cultural Cyber Crime	(3.1)/100 – (4.3) – (5.3) – (5.5)		Min = 0	Point
5.3	Cyber Law/Regulation and Enforcement	(5.4)/100			Point
5.4	Delay in Law Adoption	Delay (3.1), 36 month	Delay		Point
5.5	Social and Cultural Strength	7	Cons		Point

After all of the assumptions are created and put into the equation and algorithm, Vensim PLE is used to run four types of simulation:

1) ***Run-No Feedback and Normal Delay***. In this test, there is no feedback from the ICT usage (3.1) to the ICT infrastructure (2.1). No correction on the productivity of the ICT infrastructure (2.1), eventhough the ICT usage (3.1) has taken more than 50% of the ICT infrastructure (2.1) capacity.

2) ***Run-No Feedback and Adjusted Delay***. No feedback as explain in no. 1 above, but there are adjustments on the "Delay in Education Adoption (4.2)" and "Delay in Law Adoption (5.4)". These adjustments will minimize the cyber crime effects. The adjustments are :

a) "Delay in Education Adoption (4.2)" from 24 months into 6 months.

b) "Delay in Law Adoption (5.4)" from 36 months into 12 months.

3) ***Run-Feedback and Normal Delay.*** In this test, the diagram view is modified (see Table 3.) to take the ICT usage (3.1) as feedback to the ICT infrastructure (2.1). If the growth of the ICT usage (3.1) is very fast, the intervention is needed to make the ICT infrastructure (2.1) follow the ICT usage (3.1) growth.

4) ***Run-Feedback and Adjusted Delay.*** The feedback is in place as explained in no. 3. The adjustments are as explained in no. 2.

In SVT below (Table. 3), the ICT infrastructure (2.1) always keeps the utilization below 50% of its capacity. If the ICT Usage increases consistently to take more than 50% of ICT infrastructure, then manual intervention is given. In this case, the owner will upgrade the ICT infrastructure (2.1) with additional 50% of ICT usage.

TABLE III. STRUCTURE VIEW TABLE (SVT) OF MODIFIED FIG. 2

No.	Description	Equation	Type	Value	Unit
2.2	Productivity(Normal)	(1.2) * 0.4		Nor mal	(2.1) per month
	Productivity(Condition)	(1.2) * 0.4+(3.1)*0.5		if (3.1) > (2.1) *0.5	(2.1) per month

C. The Output of Simulation

The results of four tests are represented in some figures. In Fig. 3, the line 1 and 2 are not smooth and different from line 3 and 4. The ladder on line 1 and 2 are the effect of the correction input from the ICT usage (3.1) as the feedback to the ICT infrastructure (2.1). Without this feedback, the growth of the ICT usage (3.1) and the business activity (1.2) are slower (see line 3 and 4).

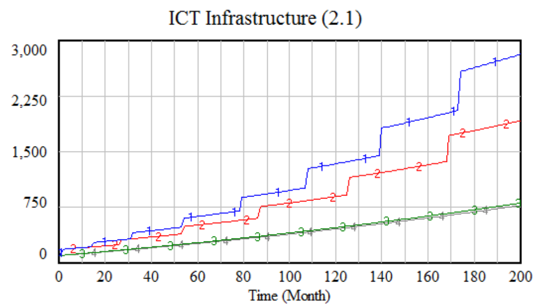

Fig. 3. Time (month) vs ICT Infrastructure (gigabytes per month)

The graph legend of simulation is the blue line 1 for "Run-Feedback and Adjusted Delay", the red line 2 for "Run-Feedback and Normal Delay", the green line 3 for "Run-No Feedback and Adjusted Delay" and the grey line 4 for "Run-No Feedback and Normal Delay".

The next test is the adjustment of delay components in adopting cyber law/ regulation and enforcement (5.4); and also ICT education (4.2). It shows that the faster it can adopt the changes on the ICT usage (3.1), the higher it can increase the business activity (1.2) (see Fig. 5). This is the good input to government to speed up process of creating the cyber law / regulation and enforcement; and designing a good program for education sector to learn the new technology.

The correction factor is identified by calculating from ICT usage (3.1) in Fig. 4 with adjusted delay (A) as line 1 and normal (N) as line 2. The formula is

$$\text{Correction Factor} = (A - N) / (N) \qquad (3)$$

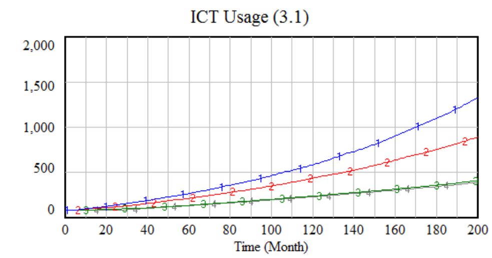

Fig. 4. Time (month) vs ICT Usage (gigabytes per month).

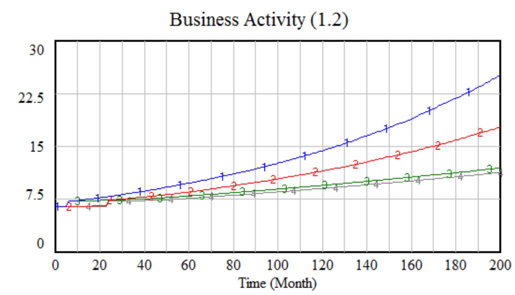

Fig. 5. Time (month) vs Business Activity (gigabytes per month).

D. ICT Capacity Planning Analysis

Based on data from ITU (www.itu.int) and Indonesian statistics bureau (www.bps.go.id), the ICT usage of Pekanbaru, one of the cities in Indonesia is estimated (see Table 4). It is assumed that the government is able to expedite the delays to minimize cyber crime effects in 2014.

TABLE IV. ICT USAGE OF PEKANBARU CITY

No	Description	2000	2001		2011	2012
1	Total Broadband Subscriber (x1000)	4	13	…	2736	2983
2	Total ICT Usage (terabytes per month)	*16*	*60*	…	*10946*	*11932*
3	Total people of Indonesia (x1000000)	206	*206*	…	*238*	*238*
4	Total people of Pekanbaru City (x 1000)	586	598	…	898	898
5	Percentage of people	0.28	0.28	…	0.38	0.38
6	Total ICT Usage in Pekanbaru City (gigabytes per month)	45	168	…	41593	45341

In Table 4, it is assumed that each broadband subscriber generates 4 gigabytes per month of traffic. The percentage of people is total people of Pekanbaru city divided by total people of Indonesia. The ICT usage of Pekanbaru city is the percentage of people multiplied by Total ICT Usage. The italic blue numbers are estimated ones.

The regression is done by assuming that the ICT usage growth is 0.9 in every year after the last data (see Table 4). This becomes ICT usage before the adjustment, or it is called as normal (N). It is normal result before applying correction factor from the simulation of the model (see Fig. 4). Equation (3) is used to calculate the ICT usage after the adjustment (A) (see Fig. 6).

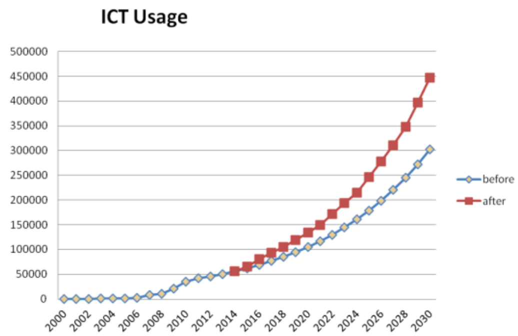

Fig. 6. Time (year) vs ICT Usage (gigabytes per month) after (A) and before (N) adjustment.

IV. Conclusions

The system dynamics is recommended methodology to identify components which are usually not seen in the classical way of capacity planning. It generates model. Most of the time, model is not a complete and ideal one. It means the behavior of model is not exactly the same as or high similarity to the real system. At least, it can be used to isolate certain components to identify how they influence the behavior of the system.

In our case, the delay on applying of cyber law / regulation and enforcement (5.4); and adoption in ICT education (4.2) are being studied. These components are related to cyber crime effects. By adjusting the parameter of these delays, it gives a better picture on the impacts of these two components in minimizing cyber crime effects, ICT usage, ICT infrastructure and ICT capacity planning process.

Many other unidentified components could influence this ICT capacity planning process as well. For further study, it is recommended to make the components more detail or break it down into smaller components. This will identify more components, and more behaviors of the system.

Even this paper is far from the exactness of the real system, but it identifies the impacts of delay on the implementation the cyber crime law / regulation and enforcement; and adoption in ICT education. The longer the process runs, the slower the people takes the advantage of the ICT infrastructure. It will become a good input not only to private company who owns ICT infrastructure, but also to the government to act appropriately and come with a good public policy.

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