A Brief Look at Software Defined Network (SDN) Implementation: Gaining Benefits and Coping with the Challenges at a Telecommunication Company

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Abstract. Information Technology (IT) is viewed as one of the capabilities in organizations that support its business model. Software Defined Networking (SDN) has become an important and integral part of the latest technology such as IoT and cloud computing because of its advantages. However, despite all the benefits, implementation of SDN is full of challenges. PT XYZ as a case study, has implemented SDN for their internal use. This study aims to make a case how PT XYZ implement SDN in general and how they cope with the challenges of implementing it. Interview and simple scoring of SDN challenge satisfaction were used in this study. It showed that the lowest score of challenge satisfaction was business dimension with score of 2.13 of 3, meanwhile the highest score was operational dimension with score of 2.88 of 3. The result of score indicate that PT XYZ are currently in the early stage of SDN implementation. They are mainly focused on making sure that the challenges in operational of SDN is handled well.

1. Introduction
Information technology (IT) has become something regular rather than something exclusive. IT cannot be competitive advantage anymore. However, IT must be part of infrastructure support of business [1][2]. PT XYZ is a company which is engaged in broad sector of areas of business such as telecommunications (mainly), information, multimedia, edutainment and services. Requirements of dynamic flexibility and scalability of telecommunication industry enforced PT XYZ to implement Software Defined Networking (SDN) on their IT infrastructure. Beforehand, PT XYZ planned to upgrade their broadband technology, and then they considered to adapt new technology which was SDN. They chose SDN to chase its benefits such as centralized configuration and scalability [3][4] despite of its concern of security [5]. PT XYZ planned a roadmap to align SDN implementation with other technologies such as cloud computing and IoT.

Previous studies resumed some challenges in implementing SDN and the benefit of it. The challenges can be on the operational side, organizational side, or business side, and each area can be breakdown into several challenges [6]. Meanwhile many other benefits gained by organization after implementing SDN, which are enabling network configuration automation Error! Reference source not found., managing and maintaining level of performance, scalability, security, and reliability dynamically and flexibly Error! Reference source not found.Error! Reference source not found., and enabling the design and deployment of third-party applications Error! Reference source not found..

This study aims to make a case how PT XYZ implement SDN in general and how they cope with the challenges of implementing it. The methods designed is summarized as these two main steps: data collection and data analysis of SDN implementation – mainly focus on analysing how PT XYZ gain benefit and cope with the challenges of implementing SDN. A brief look of it.
2. Methods

2.1. Data Collection

Data is collected and analyzed from interview and simple questionnaire. Before interview was conducted, a scoring standard was designed to be embedded into the questionnaire. The questionnaire was drafted according to [6]’s research. There were three dimensions in the questionnaire: operational, organizational and business. Each dimension had several areas and each area consisted of several challenges. Study of [6] describes list of challenges implementing SDN.

This study designed a simple scoring adapted from Likert’s questionnaire scale [11]. The scale definition was needed to get the same perception between authors and interviewees, and it was acquired by having group discussion between authors and some key persons who involved in SDN for a while at PT XYZ. Each value of this score representing a condition how PT XYZ cope with its challenge. The representation of each score can be seen in TABLE I. Beside the questions based on study of [6], some questions related to general implementation of SDN were also prepared: (a) How SDN was implemented in PT XYZ? (b) What is the benefit of using SDN? (c) What other challenges is faced by PT XYZ (outside guideline of [6])?

Interview was performed to two personnel who was involved in planning and designing SDN for PT XYZ. These key persons were also part of task force of SDN implementation in PT XYZ. One of them had working experience in networking technologies for 14 years and the other was person who has networking operational experience at least 2 years. Interview was conducted in STO building Jakarta on 15th of October 2019 from 1 PM to 3 PM. This activity aimed to get insight how SDN is conducted in PT XYZ generally and get to know how PT XYZ cope with SDN’s challenges. In this interview, a simple quantitative survey was also gathered beside the explanation how PT XYZ responds to challenges (Table 1).

| Respond Score (RS) | Satisfy when organization                                      |
|--------------------|----------------------------------------------------------------|
| 1                  | Do not know this challenge; or know this challenge but currently it is unsolved yet or it is not organization's priority to solve. |
| 2                  | Know this challenge, a part of this challenge has been solved or planned to be solved |
| 3                  | Know this challenge, solution or respond to this challenge is already addressed |

2.2. Data Analysis

Analysis was conducted by categorizing data interview into each part: implementation SDN in PT XYZ, SDN architecture, benefit implementing it, and responds of PT XYZ of its implementation challenges. Specific analysis was executed for challenges responds. It was tabularized and pivoted into graph. Responds were codified in order of RS rank from largest to smallest. The score and responds were then analyzed and reported.

3. Results and Discussion

3.1. Software Defined Network in PT XYZ

PT XYZ uses SDN as a solution that can afford the initial problem of variety of devices that have different vendors, operating systems, and chipsets. They use a vendor specific SDN. By separating control plane and data plane, PT XYZ now can finally have different boxes (devices) without worrying about how to control each device. The control will be handled by centralized control plane.

Currently SDN is used for internal use to serve core applications of IT division of PT XYZ. The implementation is in the early stage so that it still focuses on its operational. There are several technologies which are also in separate development aligned to SDN, such as the use of NFV (Network
Function Virtualization) in several building across Indonesia, Internet of Things (IOT), big data, and SDx (Software Defined Anything, for example SDWAN, Software Defined Wide Area Network).

3.2. **SDN Architecture in PT XYZ**

In SDN, control plane and data plane are separated. There are several popular SDN control plane models to be designed. Based on its data center location, PT XYZ choose to use Distributed (flat) Controller Design (DCP) model. Each controller will manage its nodes called spines and leaves. Spine will communicate directly to controller, while leaves are the border nodes that directly connect to outer devices forwarding packet.

3.3. **Benefit of Implementation**

The implementation of SDN in PT XYZ has several benefits. It has many potentials as a network infrastructure capability. SDN as a new technology in IT network infrastructure can be counted as a way of PT XYZ to renew their organization capability. In theory better capability should generate more profitable growth and more efficient capital to organization. These are some benefits that is summarized from the interview.

- **Reduce cost**: SDN offers the ability to manage multivendor under its controller and its programmable nature of SDN make its scalability easier. Thus, less effort, less time, less operational expenditure.
- **Faster delivery**: devices can be plugged and played faster under respected SDN controller. If there are needs from SBU (strategic business unit), IT division can quickly manage their network accordingly. The use of centralized controller helps them to manage it centrally.
- **Easier scalability**: having centralized controller make it easier to scale devices and network.

Other than mentioned in the interview, other benefits of implementing SDN such as centralized network provisioning, cloud abstraction, enhanced granular security, and directly programmable were also implicitly said on the interview.

3.4. **Level of Satisfaction to the Challenges of SDN Implementation in PT XYZ**

This study tried to assess level of satisfaction to cope with SDN implementation challenges. Data gathered from interview showed that there are several areas across domain still need to be addressed. Figure 1. shows about in which level of satisfaction of each domain. Table 2 showed us the codification responds of PT XYZ according to challenges that studied by Error! Reference source not found..

As this study conducted, PT XYZ is in the early stage of implementation of SDN, so that most challenges in operational dimension are already addressed. It is also caused by the scope of implementation which is for internal use. The use of vendor specific SDN can also contribute to any solutions to address those challenges in operational dimension. Detail analysis for each dimension will be discussed shortly.

In operational dimension, the only area that does not met full score is network operation as it is shown in Figure 2. Challenge of “standardization of open interfaces that facilitate uniform control and management across technologies and vendors” is not met because it is not a concern yet (Table 2, c.4). PT XYZ does not manage diverse devices and vendors yet, although the prospect that they need to procure various device in the future still there. Challenge of “network automation” is partially met. Rather than manually add each device to controller, the addition of network automation feature is helpful enough to operational team (Table 2, b.1). Although controller of SDN can already automatically find the devices in network, but the personnel of IT division still have a necessity to register its device ID (Table 2, b.1).
Figure 1. Level of satisfaction of three dimensions of challenges.

Figure 2. Level of satisfaction of operational dimension for each area of challenges.

Figure 3. shows area of challenges in organizational dimension. Only departmental organization challenge that need to be addressed. To operate SDN, PT XYZ have different division with separate skill sets. One division excels in networking, the other specialize in security, and there is also one who handle the business. This is a challenge that need to be addressed by restructuring organization or designing a clear segregation of duties between related division (Table 2, b.2). For skill challenge, they had difficulties at first to learn this concept and new terms, but eventually they manage to operate it well (Table 2, a.13). The partnership is also not a concern for them at this moment (Table 2, a.14).

Figure 4. shows area of challenges in business dimension. This is dimension that has the lowest satisfaction of score to cope with SDN implementation challenge. Main reason of this situation can be deduced by its maturity of implementation. They still focus on operational in targeted scope (handle network traffic for core application at this moment). They need to address some challenges in business domain to get leverages of SDN.

Most challenges in this domain related to enablement of new stream of revenue or generation of efficient traffic. Analytics, for example, currently not a priority for PT XYZ. If they can gain insight from the pattern of traffic, they can have something new to make at (Table 2, c.2, c.3). In customization area at the other hand, if they can enable it as a new business with a proper billing system, they can have new stream of business (Table 2, c.5). There is a challenge in area of “capabilities of sharing network infrastructure” which is PT XYZ’s regulation. At this moment, the capabilities of sharing are enabled only to its subsidiaries (Table 2, b.4). For innovation area of challenge, they already have specific division that focus on research and development (Table 2, a.20). Network and equipment lifetime can be monitored by their SDN capability, but it needs proper regulation so that it is being monitored and processed so that it benefits them (Table 2, b.3).
Figure 3. Level of satisfaction of **organizational dimension** for each area of challenges.

Figure 4. Level of satisfaction of **business dimension** for each area of challenges.
### Table 2. Respond of Challenges of PT XYZ

| Challenge                                                                 | Respond Score | Respond Code | Respond                                                                                                                                                                                                 |
|--------------------------------------------------------------------------|---------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Comprehensive network resource planning                                  | 3             | a.1          | Planning had been made thoroughly (for example capex initiation, capacity planning, and backup)                                                                                                           |
| Multilayer planning tools                                                | 3             | a.2          | It is helped using capacity planning tool provided by vendor solution                                                                                                                                 |
| Increased testing and product homologation                                | 3             | a.3          | At initiation they did prove of concept and user acceptance test was done thoroughly before its deployment                                                                                           |
| Risk of overinvestment in data center infrastructures                    | 3             | a.4          | There was a corporate IT leadership to regulate cost saving of expenditure. To accomplish that regulation, the task force handles the implementation planned risk mitigation including overinvestment risk (for example made detailed capacity plan) |
| Criticality of data centers and need for highly secure infrastructures    | 3             | a.5          | The implemented SDN is in data centre with high availability (HA) design. Current SDN policy set that outside internal network is considered “untrusted”                                                  |
| Integration with existing OSS/BSS systems                                | 3             | a.6          | It is already integrated with OSS and BSS system                                                                                                                                                      |
| Relies on Open Source developments                                       | 3             | a.7          | The solution is vendor specific currently, so no threat in interdependence                                                                                                                             |
| Control plane resiliency                                                 | 3             | a.8          | Its resiliency is well support by its distributed control plane (DCP) design. The control planes are redundant (active-passive)                                                                          |
| Decoupling of service from transport                                     | 3             | a.9          | Service is handled beyond data plane. Service is already decoupled. Network capabilities are completely supported by its solution. If there are necessity to bigger capacity, they are ready to scale up APIs in REST form are provided |
| Mapping between service requirements and network capabilities             | 3             | a.10         | There is a regulation that enforce vendor contract to ensure asset ownership duration above 5 years and vendor must ensure that organization does not have obligation to buy physical asset when there is any update in the future |
| Common APIs and information and data models                              | 3             | a.11         | There is competition in SDN market. Trend of open computing arises, so that prices and solutions are more competitive in contrast to conventional product                                                    |
| Coexistence with legacy networks                                         | 3             | a.12         | There is a need to design the solution is vendor specific currently, so no threat in interdependence                                                                                                       |
| Multidisciplinary teams                                                  | 3             | a.13         | There is a need to design the solution is vendor specific currently, so no threat in interdependence                                                                                                       |
| Larger number of partners requiring more coordination and management effort| 3             | a.14         | There is a need to design the solution is vendor specific currently, so no threat in interdependence                                                                                                       |
| Isolation and security                                                   | 3             | a.15         | There is a need to design the solution is vendor specific currently, so no threat in interdependence                                                                                                       |
| Management of a larger number of vendors                                 | 3             | a.16         | There is a need to design the solution is vendor specific currently, so no threat in interdependence                                                                                                       |
| Definition of new quotation models to compare prices and solutions respect to conventional products | 3             | a.17         | There is competition in SDN market. Trend of open computing arises, so that prices and solutions are more competitive in contrast to conventional product                                                    |
| Definition of new guarantees                                             | 3             | a.18         | Using existing partnership scheme: subscription, licensing, ATS (annual technical support), including consultant who are responsible for service & network, business team is to ensure alignment with business need, one team have expertise in operational telco devices, one team focuses on research and development, the other team have expertise in security |
| New business models for infrastructure and capacity sharing              | 3             | a.19         | The capability of network capacity sharing is available for in data centre with high availability (HA) design. Current SDN policy set that outside internal network is considered “untrusted” |
| Creation and maintenance of innovative teams                             | 3             | a.20         | Part of task force this is not a priority to control and manage across technologies and vendors                                                                                                           |
| Network automation                                                       | 2             | b.1          | Network registration process is automated (plug and play), but there is still simple manual process to register device number for registration of the device                                                                 |
| Cross-functional reorganization of departments                            | 2             | b.2          | At initiation, task force is multidisciplinary team. It is a problem that existed in data center with high availability (HA) design. Current SDN policy set that outside internal network is considered “untrusted” |
| Re-programmability of equipment to extend the service lifetime           | 2             | b.3          | Capability is there, but it needs formal standard operational procedure to make it work                                                                                                                                 |
| Impacts of regulation                                                    | 2             | b.4          | Capability of it exist and its subsidiary to use this capability.                                                                                                                                       |
| Standardization of open interfaces that facilitate uniform control and management across technologies and vendors | 1             | c.1          | Currently it is not a priority to control and manage across technologies and vendors                                                                                                                  |
| Correlation of decoupled service and transport indicators                | 1             | c.2          | No correlation analytics yet                                                                                                                                                                           |
| Big Data analytics for predictive actions                                | 1             | c.3          | No predictive analytics using big data                                                                                                                                                                |
| Standard interfaces for network service and resource consumption         | 1             | c.4          | Currently, it is not priority yet                                                                                                                                                                       |
| Proper billing mechanisms                                               | 1             | c.5          | No regulations to handle billing mechanism. Currently it is for the purpose of internal use                                                                                                             |
3.5. Other Challenges
Beside all the challenges summarized by Error! Reference source not found., PT XYZ also stated their concern about other challenges.

- Employee learning. New technology means new theory, new terms, and new methods to be learn by organization’s employee. Solution for this can be achieved by implementing good knowledge management. Well manage knowledge can have impact on employee learning whenever they are exposed with any latest technology Error! Reference source not found..

- Employee adaptability. Beside learning new technology, operational employee also needs to adapt with the changes. They manage both legacy networks and newer technology. Different user interfaces may confuse them. According to Error! Reference source not found., role of good knowledge management can be vital here as it can give impact on employee adaptability.

- Reliability of vendor solution. In the interview, it was suggested to any organization that implement SDN to ensure that the solution they choose is proven in the market. In PT XYZ’s case, there were several cases that there were bugs, but fortunately the vendor is responsive enough to help organization solve that problem.

3.6. Recommendation
Most challenges in operational dimension are already addressed, they need to make it stable by setting regulation related to SDN such us network capability sharing and clear segregation of duties among their division. They also need to start thinking about leveraging it as a business. SDN integration with analytics and big data is interesting challenge that may create new business opportunity in the future. If PT XYZ can address those challenges in both domains, they can benefit more from SDN Error! Reference source not found..

4. Conclusion
This is a brief look of one case study of SDN implementation. There are some things that we can learn from the study. This study tried to assess SDN implementation condition at PT XYZ using a simple scoring method, and it was shown that PT XYZ currently was in the early stage of SDN implementation as they were mainly focus on operational of SDN. Most challenges in operational dimension are already addressed (with the score 2.88 of 3). Business dimension has the lowest score (with the score 2.19 of 3). They need to maintain the stability of its implementation by addressing the challenges in organizational and business dimension such as enacting firm regulation related to SDN, established suitable organization, and leveraging SDN as an opportunity to new business stream. However, it is not just about implementing new technology to stay competitive, but it is about managing challenges in its processes and its people. Know where you at, know the opportunities of improvement, know the challenges to be faced, and plan well to achieve your organization’s goal.

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