# CHAPTER 1
# INTRODUCTION

## 1.1. Background

Since bandwidth is a finite resource, making the most of it and using it efficiently is undeniably critical to the telecommunications industry. Currently, in Indonesia data communications demand is still growing, especially for high speed and large of volume data quota. However, the coverage of infrastructure for data communication and internet has not been deployed to remote areas. Accelerating the fulfillment of data and internet access to this rural area is the responsibility of the Ministry of Communication and Informatics (KOMINFO) through the Provider and Financing Manager of Telecommunications and Informatics (Badan Penyedia dan Pengelola Pembiayaan Telekomunikasi dan Informatika, known as BP3TI), by optimizing Universal Service Obligation (USO) funds.

The three main programs of the USO consist of Broadband Village, Internet Access, and provision of Base Transceiver Station (BTS) in blank spot area of telecommunication facilities. The targets of these programs are for the foremost, outermost and lagging regions (terdepan, terluar dan tertinggal, known as 3T regions), in order to reduce the information access gap. The program is part of KOMINFO's strategic plan of 2015 to 2019 [16]. The target of BTS blank spot rollout until 2019 is 575 BTS, while broadband village and internet access programs are enlivened by approximately 1,000 locations each year with the target of providing for schools, health centers, village administrative offices and rural public areas.


Figure 1.1 Distribution of internet access deployment until June 2016

In accordance with the topography of Indonesia which is an archipelago country, the efforts to accelerate the implementation of these programs can be solved using telecommunication infrastructure based on satellite transmission. We can choose a satellite with coverage area that reaches the target area of telecommunication development in the 3T region, so it can be served as line of sight (LOS), with a relatively faster for the time to deliver than if it builds the terrestrial telecommunication infrastructure. For this condition, satellite communications systems that are technologically appropriate characteristics are Single Channel Per Carrier (SCPC) or Dynamic SCPC (D-SCPC).

Climatic and weather characteristics cause satellites that operate to serve telecommunication infrastructure in Indonesia mostly using C-Band frequencies that are relatively weather-resistant, especially resistant to rainfall intensity. C-Band has 800 MHz bandwidth, and works on uplink frequencies of the range 5,925 – 6,725 MHz and downlink frequency of the range 3,400 – 4,200 MHz. At least more than 35 satellites with coverage footprint reach the territory of Indonesia, either wholly or partially. However, the large number of satellites is not enough to bring the competition to the lower in price per megahertz (MHz) satellite bandwidth. In addition to the high cost of investment, the total available capacity is insufficient to meet the needs and demands of the telecommunication market in Indonesia and the surrounding region. Meanwhile, the existing satellite types are single beam satellites, so the available power is also limited by distribution based on the coverage area.

The next challenge that will arise out of the satellite communications industry is High Throughput Satellite (HTS) technology that uses the concept of multi spot beams and frequency reuse, which the transponder capacity will increase in volume and the use of satellite resources become very efficient. As an implication of this condition, the price per MHz bandwidth of the transponder will be much cheaper than regular satellites that exist today.

To address these existing limitations and challenges, as an innovation to increase capacity and utilization of satellite bandwidth in SCPC systems can be solved by applying bandwidth efficiency technology that work under the concept of Paired Carrier Multiple Access (PCMA) or Adaptive Cancellation, and in this research called Carrier-in-Carrier (CnC) [2][3]. Transponders and network configurations must be optimally managed, so it is important to analyze how significant the resulting bandwidth efficiency is as a result of the use of bandwidth efficiency in this SCPC system. Devices on earth stations that support the application of CnC technique, and directly configured are Modems.

In this research, the analysis will use some backhaul links using SCPC systems and have implemented CnC techniques, either E1 or DSL-1 (DS-1) equivalent to 2.048Mbps, or DS-1 Digital Signal level (DS- 3) which is equivalent to 44.736MBps (often called 45MBps). While to obtain more representative results of the system as a whole, satellite parameters use two types of satellites, namely Chinasat-10 ($108^{o}$BT) and Telkom-3S ($118^{o}$BT). Parameter in earth

station used three types of Modem, namely Paradise Q-Flex and Comtech CDM-750. This bandwidth efficiency will be directly correlated with decreased per link operational costs due to lower transponder costs, so we get more links and larger transmission capacity with the same operating budget.

### 1.2. Gap of The Real Condition and The Future

First research of bandwidth efficiency method in satellite communication systems, and related to frequency reuses mechanism is known as Paired Carrier Multiple Access (PCMA). PCMA is a technology which allows two different earth stations to use the same frequency, time slot, and/or code at the same time, depend on the type of multiple access that used for the systems. Researcher also explained how PCMA technology works and what the benefits offers to the systems [2].

Second, the researches mostly focus on device development based on PCMA technology in order to answer the the challenges of bandwidth saving methods in satellite communication systems. ViaSat, in 2004 has promoted a tag line "A True Breakthrough in Satellite Communications", at ArcLight Modem launching. Then, iDirect and Newtec Satcom launched their PCMA based product for point to multi point satellite communication systems. Third, in 2010, Adaptive Cancellation technology that has been patented by Raytheon Applied Signal Technology, called DoubleTalk, launch different technology to increase bandwidth utilization in satellite communication systems. As these technologies approach theoretical limits of power and bandwidth efficiency [3][4].

The last, there is a research that evaluate reuse of the same time and frequency resources for both transmission and reception, in what is known as In-Band Full Duplex, and which is being considered as a promising technology for terrestrial wireless systems. The rate limits for the exchange of information between two earth station antennas and two satellites are obtained as a function of the capability of suppressing the self-interference which is caused by the Full Duplex operation [5]. This research would like to present an evaluation and performance analysis of bandwidth efficiency implementation, that will useful to obtained the solution of satellite bandwidth capacity fulfillment which increase in order to serve the demand in eastern Indonesia.

### 1.3 Problem Definition

Since the bandwidth of transponder is limited and expensive resource, the following problems should be get solution:

- How to increase the service capacity of SCPC satellite communication systems with the existing bandwidth?
- How to increase the effectiveness of transponder to deliver SCPC systems to the market?

- What is the solution should be applied to obtained the optimum bandwidth efficiency by implementing carrier-in-carrier technique?

As we do not know how is the best combination of the related parameters, consist of satellite, carrier and link parameters, including earth stations configuration, so we can't deliver comprehensive performance analysis to produce the optimum bandwidth efficiency, and at the same time provides acceptable throughput and network availability.

### 1.4 Problem Limitations and Assumption

The bandwidth efficiency analysis of this research is directed and focused to SCPC systems that commonly used to deliver the telecommunication solution for customers, in particularly the backhaul links for telecom operators or oil and gas companies. Referring to the consideration that the links to be analyzed are under operational conditions, as well as the limitation of existing data and the timing of completion of this research, the scope of the problem is limited and assumed as follows:

1. Analysis in this research focuses on satellite backhaul link using SCPC system, especially with CnC technique.
2. This research is not discussing the details of; signal suppression, adaptive cancellation, interference cancellation process and algorithms those used in bandwidth efficiency technology, modulation, coding and multiple access techniques.
3. Variable parameters used in the analysis are the type of modulation, coding and forward error correction to obtain optimal transmission parameter profile.
4. Other devices and technical specifications of the device are in compliance with current installed, and in operational conditions.
5. Typical and standard parameters follow the parameters that state in link budget calculation tool, which are defined by international standard (ITU).
6. The calculation and simulation of link budget is done by logarithmic equation approach to simplify the conversion process to calculation tool SatMaster Pro and Microsoft Excel.
7. The results of the performance analysis were studied through literature and validated using simulations.

### 1.5 Research Objectives and Hypotheses

The objective of this research is to provide a recommendation to all parties concerning the bandwidth efficiency and transponder management using Carrier-in-Carrier technique by proposes the optimum configuration and parameters, through the following stages:

a. Calculate the link budget of some SCPC backhaul links, both the regular and those applying CnC technique.

b. Compare the value of required bandwidth and sufficiently of power, then analyze the result of each condition.
c. Proposes the best and most efficient transmission and satellite parameters that can be used to deliver SCPC system services in eastern of Indonesia.

If PCMA and DoubleTalk Carrier-in-Carrier can be applied to all of satellite communication services by performing the proposed scheme of parameters combination in this study, a more bandwidth efficiency will be obtained.

### 1.6 Research Methodology

Basically the principle of this research is to measure the efficiency of bandwidth that obtained due to the application of CnC technique on the SCPC system, then evaluated and analyzed from a practical operational point of view. Required data obtained by conducting discussions and surveys with relevant parties in telecommunication solutions provider company for Telkomsel and with related unit in charge in Telkomsel region of Papua & Maluku, as well as observation of operating conditions at hub and remote sites.

The completion of this research is carried out with the following stages:

1. Literature studies, conducted to obtain the related theoretical concepts and information, referring to journals, textbooks, manual books of the related devices, product reviews and other articles that support the research.
2. Observation and data collection from operational conditions, either from the network control center, the satellite provider or from the hub and remote earth station, which will support this research.
3. Mathematical simulation using Satmaster Pro / MS Excel application, and then analyzing data, link budget calculation and bandwidth efficiency comparability result.

### 1.7 Scope of Works

The work contains five part activities as follows:

1. Collecting data: satellite data, carrier data, equipment on earth station data, typical data from literature study.
2. Simulating the performance of backhaul link by calculate link budget of High capacity satellite backhaul link (DS3) using CnC and Non CnC technique, IDR based E1 backhaul link using CnC and Non CnC technique, IDR IP backhaul link using CnC technique.
3. Iterative calculation based on variable input parameters and validating the results.
4. Collecting data for comparison process: Capture of signal carrier from remote earth station (using spectrum analyzer) and screen shot status and configuration data from Modem monitoring tool
5. Analyzing of bandwidth efficiency result and recommendation.