Portfolio

ENGN2225 Systems Engineering Design

National Broadband Network
Improving Health Care System (Telehealth)

Research School of Engineering

College of Engineering and Computer Science

Lecturer: Chris Browne

Tutor: Nicole Blinco

Student: Minh Tri Nguyen

U5142082@anu.edu.au

Tutorial group: W11R

Table of Contents

Abstract 4

Introduction 4

1. Requirements Engineering 4

1.1 Overview 4

1.2 Application 5

1.2.1 Pairwise Analysis 5

1.2.2 Technical Performance Measurements (TPM) 5

1.2.3 House of Quality (HoQ) 6

1.3 Conclusion 6

2. System Function Definition 7

2.1 Overview 7

2.2 Application 7

2.2.1 Use Case 7

2.2.2 Functional Analysis 7

2.3.3 Concept Generation 9

2.3 Conclusion 9

3. Subsystem Integration 9

3.1 Overview 9

3.2 Application 10

3.2.1 System Boundary Chart 10

3.2.2. Functional Block Diagram (FBD) 10

3.3 Conclusion 11

4. System Attributes 11

4.1 Overview 11

4.2 Application 11

4.2.1 System Attributes 11

4.2.2 Attributes Cascade 12

4.3 Conclusion 12

5. Verification and Validation 13

5.1 Overview 13

5.2 Application 13

5.2.1 Verification 13

5.2.2 Evaluation 13

5.3 Conclusion 14

6. Design Communication 14

6.1 Overview 14

6.2 Application 14

6.3 Conclusion 15

7. Conclusion/Recommendation 15

Bibliography 17

Abstract

System engineers' job is characterised as problem solving by using a whole-of-system approach. System Engineer considers all the Customer Requirements within the system boundary as well as excluded factors that might interrupt the system. By using System Engineering Design theories, system engineers provide the verification of a solution that possibly satisfies all customers' needs. Throughout this paper, system theories will be applied to analyse the Australian National Broadband Network (NBN) system, from which improves the current system to benefit the Health Care system. System theories includes several techniques which are Requirements Engineering, System Function Definition, Subsystem Integration, System Attributes, Verification and Validation.

Introduction

What is NBN?

NBN system (NBN Co , 2014) is the open access communication network that provides a high speed broadband and telephone services. NBN is planned to give all premises i.e. home, school and workplace in Australia the connection between each other (NBN Co , 2014).

Health Care system and the NBN:

According to Australian Institute of Health and Welfare (2013), on an average day in Australia:

- 342,000 people visit a GP
- 6,800 people are transported by ambulance; a further 900 are treated but not transported
- 71,000 km are flown by the Royal Flying Doctor
- 23,000 people are admitted to hospital (including 5,000 for an elective surgery)
- 17,000 people visit an emergency department at larger public hospitals

With all these activities on daily basis, Australia spends large amount of money, estimated of $80 billion a year, nearly 10% of Australia's gross domestic product (Queensland Government, 2014). In order to reduce expenditure on Health Care system, 'Telehealth' with assistance of NBN is one of possible solution where consultations, supporting telemedicine and addressing health can be done through distance (rural and remote areas) via interactive internet e.g. video conference (NBN Co , 2014). This will provide greater comfort as well as time and cost saving (NBN Co , 2014).

1. Requirements Engineering

1.1 Overview

According to Hull et al (2011), Requirements Engineering is a concern in capturing, communicating and managing requirements that define the system. It is important to not only acknowledge the requirements in the technical world, but to also understand the user's world requirement i.e. customer and end-user requirements. This will be done by completion of a House of Quality (HoQ), which registers Customer Requirements (CRs) and translates them into measurable "services" (Shillito, 1994).

1.2 Application

1.2.1 Pairwise Analysis

Pairwise Analysis as shown in Table 1 was carried out in order to rank Customer Requirements (CRs) for the NBN, specifically, in Health Care system, and obtained which of CRs should be highly considered via allocating 1's and 0's (Dym & Little, 2008).

1: More important 0: Less important	Short waiting time	Secure connection	Fast	Always available	Reliable	Low cost	Score	Rank
Short waiting time		0	0	0	0	0	0	**6**
Secure connection	1		0	0	1	0	=2	**4**
Fast	1	1		0	0	1	=3	**3**
Always available	1	1	1		1	1	5	**1**
Reliable	1	0	1	0		1	=3	**2**
Low cost	1	1	0	0	0		=2	**5**

Table 1: Pairwise Analysis - Comparison Chart

Table 1 shows that 'Reliable' and 'Fast' have the same score; however, 'Reliable' was ranked higher than 'Fast'. This due to the fact that in some situation, system reliability is highly considered over 'speed'. 'Always available' was ranked as the highest requirement since in emergency situation, connection between patients and doctors is crucial.

1.2.2 Technical Performance Measurements (TPM)

The ranked CRs were translated into Design Requirements (DRs) which are referred as measurable requirement since it is possible to quantify and assign a technical attribute (Zairi, 1994). Each CR might have more than one DR and each DR was assigned with an identification code as shown in Table 2. Particularly, the top three CRs was selected to translate in to DRs. In addition, despite the fact that 'Low cost' was not highly considered, analysis on this factor is essential since it has an effect on End users.

Customer Requirement	ID	Design Requirement
Always available	DR01-01	Coverage
	DR01-02	Accessibility
Reliable	DR02-01	On-demand access
Fast	DR03-01	Down/Up stream
Low cost	DR05-01	Low up-front cost
	DR05-02	Low ongoing cost

Table 2: CRs - DRs Translations

From Table 2, the CR 'Always available' was translated into 'Coverage' and 'Accessibility' which mean once the NBN roll out, it has to cover the whole population includes rural and remote areas. Futhermore, 'Reliable' was intepreted as 'on-demand access' and 'Fast' as 'Down/Up stream' which mean when needed, NBN system should function properly and with fast own/up stream. Finally, 'Low cost' was refered to low 'up-front cost' and 'ongoing cost'; this implied that customers would prefer low initial invesment as well as monthly payment.

With the aim of comprehensive understanding the customers' needs, these DRs was intepreted further into Engineering Characteristics (ECs) with its associated measureable metric unit (TPM) as per Table 3.

ID	DRs	Engineering Characteristics		TPM
DR01-01	Coverage	+	Population coverage	% (percentage)
		+	Geographical coverage	% (percentage)
DR01-02	Accessibility	+	Node Capacity	Connection per Node
		-	Outage	Day per year
DR02-01	On-demand access	●	On-demand access	Yes/No
DR03-01	Down/Up stream	+	Line rate	Kbps (Kilo bit per second)
DR05-01	Low up-front cost	-	Equipment's cost	$AUD
DR05-02	Low ongoing cost	-	Monthly cost	$AUD/month

Table 3: Technical Performance Measurements

As shown in Table 3, DR01-01 'Coverage' has two characteristics which are 'population and geographical coverage' measured by percentage (%). These two characteristics need to be increased to ensure NBN coverage throughout the nation; hence a + sign was attributed to them as well as 'Node Capacity and Line rate'. In the contrary, - sign was assigned towards both ECs 'Equipment's and monthly cost', which indicates desired reducing expenditure.

1.2.3 House of Quality (HoQ)

Data retrieved from preceding analyses were used to build the HoQ as shown in Table 4, which summarises all results. In the HoQ, all DRs was rated as their Relative Importance, in which 'On-demand access, coverage and accessibility' were the top three respectively. On the other hand, cost was shown as the least important; however, customer's expenditure still has to be taken into account. Furthermore, the HoQ also determines the relationship between each EC and DR whether they have weak, medium or strong relationship denoted as '1, 3 or 9' correspondingly. Although 'on-demand access' was rated as most significant factor, its relationship to ECs is weaker than 'accessibility' which reflects the CRs ranking above.

+	Correlation
−	Trade-off
1	Weak relationship
3	Medium relationship
9	Strong relationship
%	Percentage
C/N	Connections per Node
Kbsp	Kilo bit per second
$	Australian Dollars

ID	Design Requirements	Relative Importance	Population coverage	Geographical coverage	Node Capacity	On-demand access	Line rate	Equipment's cost	Monthly cost
	Engineering Characteristics		+	+	+	•	+	−	−
DR01-01	Coverage	2	9	9	1	3			
DR01-02	Accessibility	3	9	9	9	1		1	1
DR02-01	On-demand access	1	3	3	3	9	1	3	3
DR03-01	Down/Up stream	4					9		3
DR05-01	Low up-front cost	6	1	1	3			9	
DR05-02	Low ongoing cost	5	1	1			3		9
		TPMs	%	%	C/N	Yes/No	Kbsp	$	$

Table 4: House of Quality

The most important part of the HoQ is to identify the correlation (denoted +) and possible trade-off (denoted -) between ECs. As indicated in the 'roof' of HoQ, both ECs of 'coverage' correlate to each other as well as 'node capacity' which mean increasing in coverage leads to enlarging connection per node. The trade-offs between cost and line rate (speed) were also discovered, from which increasing in cost will intensify the data rate.

1.3 Conclusion

In conclusion, DRs which are 'on-demand access and accessibility', have the strongest and consistent relationship to ECs. These DRs are features that will be focused during the design process. In addition, correlations and trade-offs between ECs were also determined which will assist the decision making. Observation from the HoQ suggested that as 'Node capacity' increases, 'population and geographical coverage' also increase; moreover, cost was consider as trade-off to line rate. However, even though cost was not primarily concerned, escalation in end-users' expenditure needs to be avoided.

2. System Function Definition

2.1 Overview

System Function Definition is the analysis that was carried out during system designing process. This includes Use Case, Functional Analysis and Concept Generation. The Use Case describes how the system should response to a request of stakeholders (Cockburn, 2001). Furthermore, Functional Analysis identifies, describes and relates functions that a system must perform to achieve a specific goal (NASA, 2007). Additionally, Concept Generation (Ulrich & Eppinger, 1995) is the process that starts with CRs and results in a set of solutions from which will be used to make a final decision. Having good Concept Generation and Use Case will reduce likelihood of overlooking of requirements and design functions (NASA, 2007).

2.2 Application

2.2.1 Use Case

Patients and medical staffs were identified as the primary actor in the Use Case of telehealth system using NBN with the goal of stable, reliable and high quality communication via broadband. In addition supporting actors such as service technicians who provide technical supports and maintenance were also discovered; however, their interactions with the Telehealth system were not prioritised in this report. In order to setup an online communication between patients and medical staffs, multimedia devices and software applications are needed. The most important factor within the communication system via broadband is the connection between multiple premises which primarily done via 'cable' from node to node and node to premises.

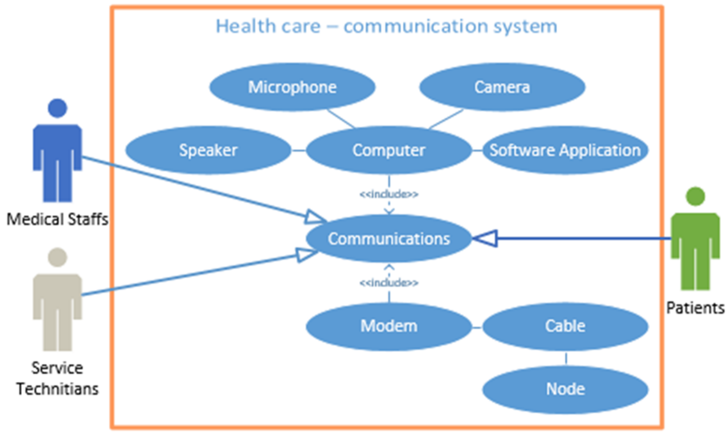

Figure 1: Use Case of Telehealth System

2.2.2 Functional Analysis

Functional Analysis arranges functions that represent operations primary actors must perform and responses from system in a logic sequence as top level function and the decomposes them into lower sub functions (System Engineering Fundamentals, 2001). In order to illustrate functional analysis, a Functional Flow Block Diagram (FFBD) is used and the benefit of using it is traceability from lower level to top level with consistent numbering scheme (NASA, 2007). The FFBD for Telehealth system as shown in Figure 2 below was built base on the Use Case discussed above.

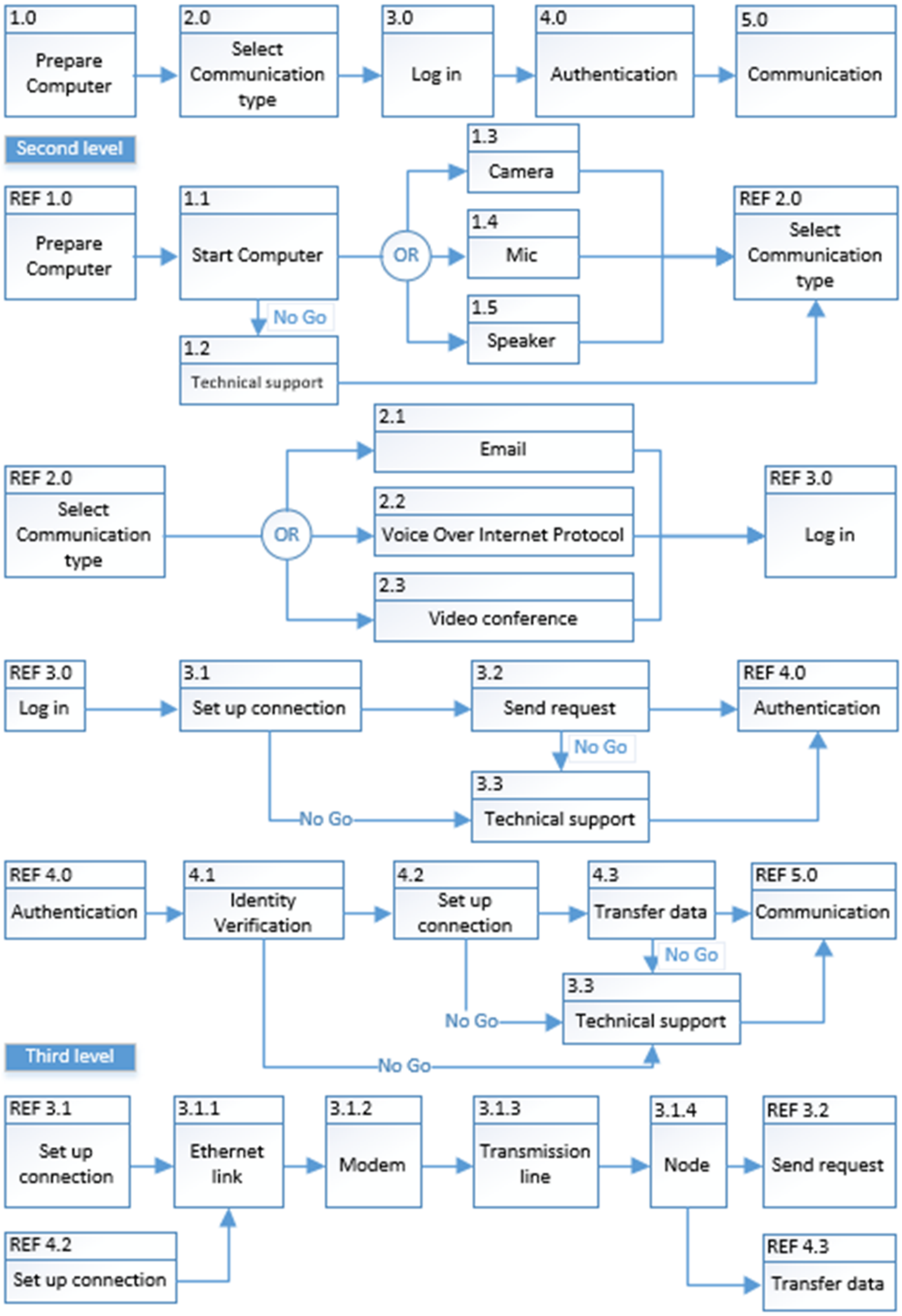

Figure 2: Functional Flow Block Diagram of Telehealth system

Figure 2 only shows a partial FFBD of Telehealth system, which does not decompose ‘Technical support’ (No Go) into subsystem. In fact, this project only focus on the use of NBN that benefit Health Care system; particularly, concentrates on second level sub function REF 3.0 and REF 4.0 as well as third level sub function ‘set up connection’. These sub functions are vital in the whole system since they play an important role in setting up connection, transferring and receiving data. Specifically, ‘transmission line’ in third level sub functions is the only connection between local devices to the outside world the to the end receivers.

The ‘transmission line’ between ‘node’ in the current NBN is fibre. However, from ‘node’ to premises, copper wire was used as transmission line which has lower data rate (Kbps) and higher probability of losing data as bandwidth increases (Hertz). In conclusion, Transmission line failures would cease the whole system.

2.3.3 Concept Generation

Concept Generation analysis in the early stage helps reduce likelihood of overlooking of requirements and design functions (NASA, 2007). In Telehealth system, observation from FFBD showed that 'transmission line' is the crucial part of the system. Therefore, the alternative for copper wire (current NBN's cable from node to premises) would be fibre. According to Cable Depot (2009), the comparison chart of copper versus fibre is shown in Table 6 below.

	COPPER	FIBER
BANDWIDTH	MAX. IS 1 GIGABIT	10 GIGABIT AND CLIMBING
FUTURE NEEDS	CAT 7 IS STILL BEING DEFINED	VERY EXPANDABLE AND IS EVOLVING
DISTANCE	100 METERS @ 1000 Mbps	40 km+ @ 10,000 Mbps
NOISE	Negative response to EMI/RFI and Voltage surges	No Effect
SECURITY	Easily tapped into	Almost impossible to tap
PULL-STRENGTH	25 pounds	100-200 pounds

Table 5: Comparison chart - Copper versus Fibre

Source: http://www.cabledepot.com/05DTFIBVSCOP.html

Table 6 clearly shows that fibre is the better material for transmission line since it has bandwidth of 10 Gigabit, which 10 times faster than copper and still promising even better performance. This would satisfy 'fast' requirement of customer. Furthermore, fibre not only has low noise effect but also more difficult to be exploited. These characteristics of fibre provide a stable and secure data transmission which meet the CRs of 'Secure connection and Reliable'. However, fibre installation would increase 'up-front cost' at end user since it requires specific skills for terminations.

2.3 Conclusion

In conclusion, Functional Analysis help identify the most important factors that might cause system failures. By using Concept Generation on those factors, fibre is evidently found to be better solution. However 'low cost' requirement is compromised. This was also foreseen in the HoQ as 'cost' would be trade-off to 'line rate'. Since human health is priceless, this trade-off is acceptable.

3. Subsystem Integration

3.1 Overview

System Engineering involves breaking down a problem into modules and solving each module individually. The modules are then linked to each other and are used to derive the solution for the problem. This method of integrating the various components of a system or a problem is known as Subsystems Integration (Torgerson et al., 2013). Subsystems Integration is achieved by using Functional Block Diagrams (FBD). The primary aim of the FBD is to display how the subsystems are related by a measureable factor despite being remotely related within the entire system as well as identify the outputs yielded by specific subsystems from their respective inputs. This diagram gives an overview of how the inputs into the system lead to certain outputs as well as how inputs among the subsystems lead to the others.

3.2 Application

3.2.1 System Boundary Chart

The various factors and subsystems within the Telehealth system were initially identified and put into a System Boundary Chart. A system boundary chart summarizes the scope of a model by listing which key variables is included endogenously, exogenously and excluded (Sterman, 2000). By analysing FFBD and Use Case, internal subsystem and external factors that interact with Telehealth system were classified and put into System Boundary chart as per Table 6.

INTERNAL	EXTERNAL	EXCLUDED
Computer	Patients/Medical staffs	Weather
Local Network	Service technicians	Power Plant
NBN	Power supply	
Technical supports		

Table 6: System Boundary chart

In addition, some excluded factors such as 'Weather and Power Plant' was added in the System Boundary chart. Although these factor are omitted, they might affect the system as under critical weather conditions (disasters), NBN might be ceased. Furthermore, the whole system run on electricity; hence functioning of Power Plant also might cause system failures.

3.2.2. Functional Block Diagram (FBD)

The various subsystems have been broken down and have had its characteristics identified. Through the process of partitioning, studies are conducted in evaluating the different design approach that can be followed in responding to a given functional requirement (Blanchard, 2011).

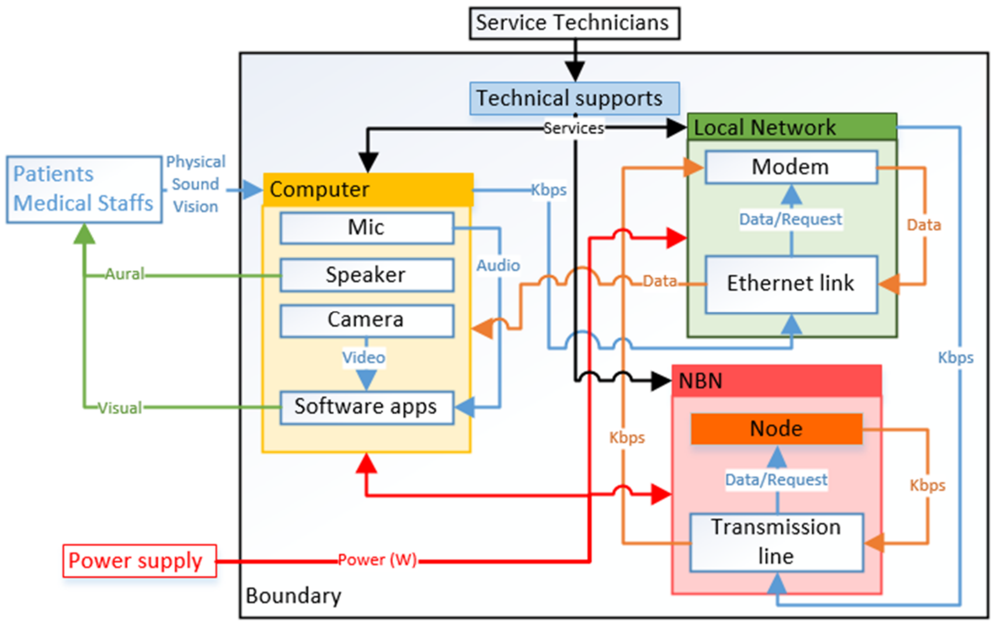

Figure 3: Functional Block Diagram

Thereby, the System Boundary chart is used as a border to depict what goes within the Telehealth system. The external factors that were identified will interact with the internal subsystems via a definable relationship. In addition, subsystems within the boundary can also have internal interactions, as shown in Figure 3.

Despite the fact that 'Power supply' was shown in the FBD, it interacts with all the subsystems (supply power; however, it was not prioritised. In fact, interaction between patients/medical staffs (external) with the system is concentrated. However, they only interact with 'Computer' physically and receive 'aural and visual'. Majority of interaction happens within the system boundary which is interactions between computer (accessories), local network (modem and transmission line) and NBN (node and transmission line). All these internal interactions are two-way transmissions which totally rely on transmission line. Furthermore, subsystem 'Technical support' was shown but not expanded. Nonetheless, it provides several services to all subsystems. Inadequately supporting services would create system latency or even failures.

3.3 Conclusion

From the above analysis of the FBD, the relationships between the different subsystems are sufficiently modular. FBD also shows that transmission line is the crucial part of the system, from which, combines with System Function Definition analysis, fibre should be highly considered. In addition, although the main purpose of this project is the Use Case of NBN in Telehealth system, 'computer' subsystem would also be an important part, improving its characteristics and technical specifications would also improve system function from which input and output high quality data (audio/video).

4. System Attributes

4.1 Overview

System attributes is a tool used to relate CRs to subsystems (Smiths & Bahill, 2009). This is important as the alteration of CRs can be easily traced back to the subsystems to help make decisions (Smiths & Bahill, 2009). The same is also true if the sub-systems must be changed for some reason. The effects can be traced back up the cascade to determine which of the attributes and which of the CRs are affected, thereby ensuring it meets the CRs.

4.2 Application

4.2.1 System Attributes

The DRs from Table 2 (Requirement Engineering) were used to derive the System Attributes, whereas Table 7 exhibits how each attribute will affect the DRs. When the system no longer has an attribute, it is obvious how the DRs are compromised or improved, which will be reflected when changes are made.

ID	ATTRIBUTE	DESCRIPTION
A1	Coverage	The NBN system should cover the whole population.
A2	Accessibility	Ensure the connection availability.
A3	On-demand access	NBN is available when needed.
A4	Down/up stream	The data transferring rate should be fast.

Table 7: Primary Attributes and Descriptions

4.2.2 Attributes Cascade

The Attributes Cascade shows how the system affects the attributes on a subsystem level. In the case of this project, 'A1 Coverage' can be satisfied by number of node and node to node link. In order to achieve secondary attribute, tertiary attributes were identified. The subsystems that were discussed in the System Integration are linked to the attributes to show the effect of changing the system. Table 8 below exhibits the Attributes Cascade for this project.

PRIMARY ATTRIBUTE	SECONDARY ATTRIBUTE		TERTIARY ATTRIBUTE		RELATED SUBSYSTEM
A1.0.0 Coverage	A1.1.0	Maximise number of node	A1.1.1	Maximise premises per node	NBN
			A1.1.2	Optimise node to premises distance	NBN
	A1.2.0	Node to node link	A1.2.1	Decrease node to node distance	NBN
			A1.2.2	Maximise link bandwidth	NBN
A2.0.0 Accessibility	A2.1.0	Maximise available time	A2.1.1	Maximise premises per node	NBN
			A2.1.1	Optimise maintenance time	TECH
A3.0.0	A3.1.0	Reduce outage time	A3.1.1	Optimise maintenance time	TECH
On-demand access	A3.2.0	Maximise cable bandwidth	A3.1.2	Use the most suitable cable	NBN
A4.0.0	A4.1.0	Maximise cable bandwidth	A4.1.1	Use the most suitable cable	NBN
Down/up stream	A4.2.0	Provide list of	A4.2.1	NBN –certified modem/Router	Local Network
		recommended devices	A4.2.2	Encourage the use of latest WLAN	Local Network

Table 8: Attribute Cascade

The Attribute Cascade clearly shows that majority of tertiary attributes relate to NBN subsystem. This is because of real-time distance communication completely relies on NBN via premises to multiple node to other end of communication. In addition, 'NBN–certified modem/Router' relate to Local Network subsystem. Even though these attributes also affect the 'Down/Upstream' attribute, they depend on the end user customisation; hence, to ensure the 'Down/Upstream' requirement ('fast' requirement), recommendation of appropriate devices (Modem/Router) or wireless standard (WLAN) is essential.

Table 8 also shows some overlapping attributes such as 'Maximise premises per node', 'Optimise maintenance time', 'Use most suitable cable'. The reason behind the overlapping is the identified correlation between ECs of DRs (primary attributes) in the HoQ (Requirement Engineering). This means these attributes will solve multiple primary attributes; however, miscarrying these attributes will compromise several DRs.

4.3 Conclusion

In conclusion, Attribute Cascade emphasises that NBN is an important subsystem, in particular, transmission line. Future changes in design and requirements will change how the system satisfies these requirements. This means that the System Attributes table and the Attributes Cascade will continue to influence the project right up until its completion. This will be especially important in the validation phase where this process will be used to refine the system until all requirements are reasonable met.

5. Verification and Validation

5.1 Overview

Verification is the process used to determine whether or not a design meets the standards set by the pre-determined systems attributes. The purpose of the verification process is to ensure that the end product is the same as the product required by the customer and this is achieved through a series of tests. The stages of testing include analytical models, Proof-of-Concept, system prototypes, operational testing and support testing (Blanchard, 2011). It is important to create testing procedures for each stage of these stages.

System evaluation is the process by which the design option that best suits the customer requirements is chosen. Although there are many types of design criteria, for the purpose of this paper the focus will be on weighted rankings and comparisons across a standard. The best way to illustrate these criteria is through the use of an evaluation matrix.

5.2 Application

5.2.1 Verification

The Attribute Cascade found in Table 8 will be used as the basis of verification process. The first step of verification process is to determine which type of test can be used on specific attribute. The attributes ‘Maximise premises per node’, ‘Optimise node to premises distance’ and ‘Decrease node to node distance’ could possibly be tested at the analytical stage, since they can be clearly shown on an appropriate drawing software which will give perspective early on in the project. In addition, Proof-of-Concept testing would be applied for the attributes similar to ‘Line bandwidth’ and “Cable technical specifications’. Finally, attributes such as ‘Modem/Router’ and ‘WLAN’ do not need to be tested since they are standardised and available on the market. However, although NBN is a subsystem in this Telehealth system, NBN by itself is a national scale system; therefore a costly operational testing could be potentially used. The advantage of operational testing in this system is that multiple attributes can be tested concurrently as shown in the example below.

Operational testing procedures: test all attributes in Table 8 except for A4.2.1 and A4.2.2

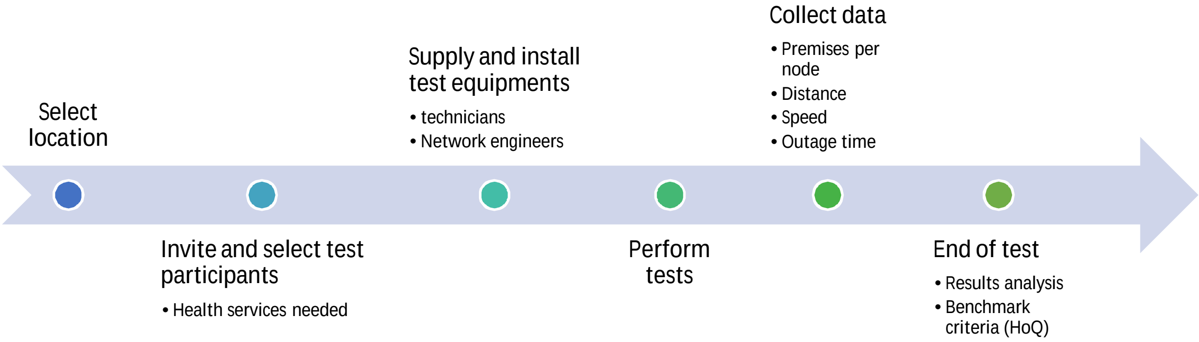

Figure 4: Operational testing procedures

5.2.2 Evaluation

System evaluation takes the advantage of resources from prior developed processes up until this point. Taking into account CRs, Pairwise Analysis (PA), FFBD and the Attribute Cascade, a meaningful evaluation matrix was produced as shown in Table 9. The evaluation matrix compares design alternatives, scoring them by how well they comply with the CRs. The design alternatives compared in this process are copper and fibre which are different materials for transmission line.

Scale 5 = Exceeds Compliance 3 = Full Compliance 1 = Partial Compliance 0 = Non-compliance	Weighting		Copper		Fibre	
	Rank	Weighting	Relative Compliance	Weighted Value	Relative Compliance	Weighted Value
Always available	1	5	5	25	5	25
Reliable	2	4	1	4	5	25
Fast	3	3	1	3	5	25
Secure connection	4	2	1	2	5	25
Low cost	5	1	5	5	1	1
	Totals			39		101

Table 9: Evaluation matrix

Ranked CRs was put into the matrix with their associated weighting. Compliance score of 5 was given to both design alternatives since both of them could satisfy 'Always available'. Observing from the comparison chart in Concept Generation (Table 5), fibre was given a score of 5 in complying with 'Reliable, fast and secure connection', while copper scores 1. In addition, score of 5 was given to copper and 1 to fibre when consider 'low cost' requirement. This due to fibre requires skilled technicians and special equipment; hence up-front cost will increase (Concept Generation).

After giving compliance scores, total weighted value were calculated as per Table 9. It is obvious to see fibre has a significantly higher total score over copper even with much lower score in complying with 'low cost'.

5.3 Conclusion

However, relative compliance is simply an estimation at this point and so any errors in estimating could have a significant effect on the outcome. Therefore, aiding from different stage of tesing as discussed in Verification section would help to improve the evaluation matrix. Hence, continous Verification and Evaluation is essential in the design process to ensure that the design meets the pre-determined CRs.

6. Design Communication

6.1 Overview

The final stage of a design project is to present the solution to client in such an interactive way. Design communication, or prototyping, in effect, aids in improving the design quality as further interviews or discussions enhances what should or should not be in the design (Shwom, 1999). Virtual prototyping is considered as a sensible approach for systems communication as it not only exhibits a model shown onto a computer, but gives an entire aspect on the life cycle of the system as well as a visual manifestation of how the design should work (Li, 2004). However, different designs with different targeted customers, selecting an efficient way of communication is crucial.

6.2 Application

The Telehealth system (NBN application) have a goal of aiding people who needs medical attention, reducing cost and time waste. Since targeted customers have wide age range and various professional backgrounds, therefore, several types of communication have to be considered. As this paper only describe the Use Case of communication between patients and medical staffs (online video conference), which was a fraction of NBN application for Telehealth. Therefore, these types of communication listed below could be applicable:

- Website that includes how the system works, which services are offered, system requirements, how to apply, and how to use the system; also includes e-brochure and videos of several case study (Introducing Barton Telehealth, 2014).
- Brochure (hard copy): briefly describe how Telehealth works (as per Use Case), show the cost effectiveness, time saving, flexibility and also safe and security of the system, from which addressing that communication with a specific qualified hospital or medical centre via broadband is feasible. The brochure should also have contact details and how to apply as well as reference the website.
- Video of system introduction and several case studies. This should expand the information in the brochure.
- Poster: compact information about the system and reference the website.
- Seminar: create workshops across hospitals and medical centres that allow customers interact with the system (prototype).

Case study that can be in the brochure or video:

- Aged care: medical staffs checking on elderly people, reminding of taking medicine etc. via broadband.
- Rural and remote areas: having consultation of specialist from far distance.

With these type of communication, the system would be introduced to customers by placing brochure and displaying video in public area such as Post Office, hospital and medical centre etc. In addition poster could be displayed on public transportation such as bus.

6.3 Conclusion

In conclusion, all types of communication discussed above could introduce Telehealth system and how it benefit customers in many interactive ways. In addition, it would be worthwhile to show customers the comparison between NBN using copper and fibre as the outcomes of the system are changed regards to latency, quality of audio and video. This can be done during seminar or having two videos using two types of transmission line.

7. Conclusion/Recommendation

By using System Engineering Design with the six analytical techniques mentioned above, a-whole-system approach was taken by using certain system techniques to improve the Health Care system using NBN (Telehealth). This led to the verification that fibre optic is possibly the most suitable material for transmission line in NBN. Even though this is an expensive solution and would increase end users expenditure, design of NBN using fibre is highly considered since it is important when it comes to human health.

However, this paper only focus on the NBN-transmission line and have not considered other functions and subsystems shown in the FFBD and FBD. There might be factors that could be improved which will lead to better outcome of the whole system. Therefore, these sub functions and subsystems should also be analysed which are computer accessories and software applications. In term of computer accessories, better devices will capture and playback with higher quality (audio and video). In addition, software applications should have a friendly interface since targeted customers could be in aged care and they might not be able to interact with a complex interface.

Furthermore, considering ‘technical support’ subsystem is also important, since it has several subsystems within it that will provide services to the entire system, including IT support and maintenance. Analysis of this subsystem could clearly show how many service technician would be needed for a specific number of node so that the response time can be estimated; hence a solution. Quick response time will help to reduce the system latency.

Other than cable internet, NBN also offers fixed wireless and satellite internet. Analysis on those technology might change the design for Telehealth system with respect to geographical map. Additionally, Telehealth system can also have several other Use Case, which has extra requirements. Consequently, all the analyses will change, and the final design might change.

Bibliography

(2013). Retrieved from Australian Institute of Health and Welfare: http://www.aihw.gov.au/australias-health/2012/spending-on-health/

(2014). Retrieved May 19, 2014, from Queensland Government: http://www.business.qld.gov.au/invest/investing-queenslands-industries/investing-queenslands-ict-industries/investing-e-health-industry/advantages-bringing-e-health-business

(2014). Retrieved March 30, 2014, from NBN Co : http://www.nbnco.com.au/nbn-for-home/how-it-works.html

Blanchard, B. F. (2011). *Systems Engineering and Analysis* (5th ed.). Pearson.

Cockburn, A. (2001). Writing Effective Use Cases. Addison Wesley.

Dym, C., & Little, P. (2008). *Engineering Design: A Project Based Introduction* (3rd ed.). Wiley.

Hull, E., Jackson, K., & Dick, J. (2011). *Requirements Engineering* (3rd ed.). Springer.

Introducing Barton Telehealth. (2014). Retrieved May 23, 2014, from Barton Associates.

Li, B. e. (2004). The recent research on virtual prototyping engineering for complex products. *Computer Supported Cooperative Work in Design.*

NASA. (2007, December). *NASA Systems Engineering Handbook.* Retrieved March 16, 2014, from http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080008301_2008008500.pdf

Shillito, L. (1994). *Advanced QFD: Linking Technology to Market and Company Needs* .

Shwom, B. e. (1999). *Engineering Design and Communication: A Foundational Course for Freshmen, Language and Learning Across the Disciplines.*

Smiths, E., & Bahill, T. (2009). Attribute Substitution In Systems Engineering.

Sterman, J. (2000). *Business Dynamics* **-** *Systems Thinking and Modeling for a Complex World.* McGraw Hill.

System Engineering Fundamentals. (2001). Fort Belvoir, Virginia: Department of Defense - Systems Management College.

Torgerson, M., Durazo, P., Langley, T., & Ragavassamy, V. (2013). *Using system engineering techniques to accelerate your next project*. Retrieved from Embedded: http://www.embedded.com/design/prototyping-and-development/4422991/Using-system-engineering-techniques-to-accelerate-your-next-project

Ulrich, K. T., & Eppinger, S. D. (1995). *Product Design and Development.* McGraw-Hill.

Zairi, M. (1994). *Measuring Performance for Business Results.* Chapman & Hall.