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IMPACT OF DISASTERS IN SOUTHEAST ASIA ON MALAYSIAN COMPUTER NETWORKS

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ABSTRACT

Disaster is an old challenge to the human society, which is continuously presenting new threats to society and its way of life. Thus, it is important for us to find ways to help mitigate these threats and to provide the society with better solutions to cope with disaster. Over the past decades, disasters have also caused damaged to telecommunication infrastructure, and thus affecting computer networks. In the world that now depends heavily on Internet and computer-based communication, damaged to computer networks will cause a lot of problems to any countries. Most of the work that address the issue of disasters and computer networks role focuses on reestablishing services after the impact. Although this is important, much research is needed in anticipating their impact of disasters on computer networks. This paper aims to propose a model for evaluating changes in Malaysian computer networks traffic caused by a regional disaster in some other part of South East Asia. The model deals with the possibility of a disaster that triggers additional disasters that may lead to more network failure.

Keywords: *Disaster Planning, Network Planning, Network Survivability, Telecommunication.*

1. INTRODUCTION

Disasters are becoming more appealing to scientists than ever, along with the ongoing debate about global warming and climate change. As politicians are pointing fingers and trying to find a way to fund the “Save Earth Campaign”, scientists and researchers are focusing on the ways to minimize the side effect those global environmental variables on human life and human way of life as well as those of other living things [1]. Joshi et al mentioned that different types of disasters have one thing in common; which is the ability to cause damage to the society and its infrastructure, thus effecting society’s way of file [2].

Nowadays terms like disaster management and disaster mitigation are starting to be more common, due to the ongoing calibration among activists in different fields, who are joining effort in order to achieve the most in this area.

To address disaster is not an easy job, and to do it properly, efforts must be combined. As for IT specialists and computer scientists, the effort is still at its beginning, for the field that deals with disasters namely “survivability” is rather new. It was ignored for a long time because it was a rare event to happen and its complicated nature made it very costly. So no one was ready to put a large sum of money and effort to study an event that is not very likely to happen, especially when there are much more profitable applications to focus on.

However, in recent years, this subject started to gain attention, due to the increase dependency on computer systems and computer networks. Most people are now realizing that the outage and down time become so expensive, making addressing the issue of survivability a very important issue [3].

Among few IT and computer science researchers who studied survivability, very few of them choose to deal with disaster based survivability, and the few who did mostly focused on post disaster studies [4]. [2] mentioned that the only area that gained some attention from computer scientists is related to the issue of maintaining system operations and data recovery after disaster. As the threat of disaster seems almost at the door step it is about time for

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researchers to start including IT plans as an important part of disaster planning.

The aim of this paper is to propose a model for evaluating changes in Malaysian computer networks traffic caused by a regional disaster in some other part of the South East Asia. The model deals with the possibility of a disaster that triggers additional disasters that may lead to more network failure. The proposed model can be used in network planning activities in order to ensure that disruptions to network services in Malaysia due to regional disasters can be avoided.

Through the rest of the paper section 2 will address disasters and computer networks and the effect each have on the other. Section 3 focus on survivability, its meaning, disaster studies' and some of disasters research that focus on survivability. Section 4 discuses modeling survivability foe Southeast Asia's computer networks, one of the previous models on survivability, its difference from the proposed one and a description of the proposed model. The fifth section includes conclusion from the current work and anticipation of the rest of work to be done.

2. COMPUTER NETWORKS AND DISASTER

The relationship of computer networks to disasters comes in two related parts:

- Its vital role in every day's life since computer network is now considered to be the most important medium of communication. A network failure will cause a lot of problems to any society.
- Its importance on disaster time operations and post disaster operations.

Network failures can be an event that triggers a disaster, a disaster generated from network failure is a technological disaster. Sometimes some scheduled or accidental network event can storm the network with control massages. that can cause more failure [5].

Today's computer network is not a local matter; but rather a global connection where each part is important to another in one degree or another. Meanwhile disasters are also being addressed in global prospective. In other words when a disaster happen it impacts on computer networks, that impact will not be limited to the disaster zone but would have different effect on other networks elsewhere.

Therefore network disaster planning must be part of any disaster plan, and it must have wide prospective of such events impact scope. That is way it is important to have studies that analyze and plan for those events on the regional and local domain. This research focus on the disaster impact on locale computer networks, what is most likely to be effected, what part is likely to be safe and how to use that for best results both locally and regionally.

3. SURVIVABILITY AND DISASTER SCENARIOS

3.1 SURVIVABILITY

In terms of computer networking, survivability can be defined as the capability of the computer network to maintain essential services [6]. Another definition for survivability is the capability of a system to fulfill its mission, in a timely manner, in the presence of attacks, failures or accidents [7]. Based on these two definitions, we can conclude that survivability is the ability of a network to preserve its services, even when a part of the network is compromised or failed.

This subject is not addressed as part of fault management because fault management deals with a single failure, whereas survivability addresses cases where double, triple or more failures happen simultaneously.

Survivability is mainly about failures and, failures can be classified in accordance to:

(1) Number of failures (double, triple or multiple).

(2) Type of failure (link, node or both).

The case of triple or more failures of any type is considered a disaster, and when failures share a geographical region then it is called a regional failure [4, 8]. Such events might occur due to accidental reasons (e.g.: floods, earthquakes, fire) or due to deliberate actions (wars, nuclear attacks or malicious attacks targeting the computer network). Such cases leave a considerable part of the computer network out of service affecting the end to end network flow and may cause partitioning in the computer network.

Most studies that address disasters fall in one of the research fields shown in Figure 1.

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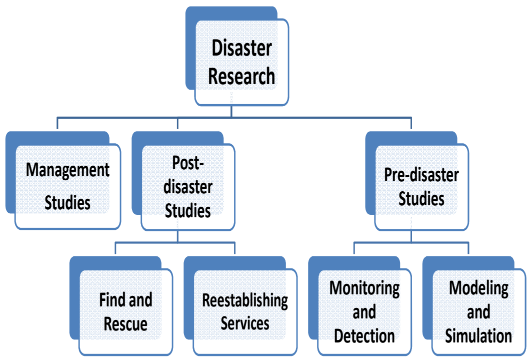

Figure (1) Disaster Studies Categories

Some researchers focus on managing disaster related issues such as dividing responsibilities, coordinating logistic efforts or facilitating data flow to relevant parties such as [9], [10], [11], and [12] . Work in post-disaster studies either discuses rescue operations in disaster infected areas, such as [13] and [14], or study ways to improved services in disaster zone by providing infra-structure related services (for examples electricity, hospitalization or network coverage) such as [15], [16] and [17]. On the other hand pre-disaster studies either discuss monitoring disasters' causes such as by [18], [19] and [20], or analyze disasters' impact through modeling and simulation such as [21], [22], [23] and [24].

Research in network survivability addresses disaster from two perspectives:

(1) How to reestablish computer network services in impact areas in the minimum time?

(2) How to minimize the events impact on services in other parts of the computer network?

Both research lines may be subjected to pre-disaster or post- disaster studies. In this research we conduct pre-disaster analyses to decide the regional disaster based variables that are significantly related to domestic computer networks, in other words to determine which disaster that will trigger failure possibility on what computer network, in order to plan a survivability strategy for such events.

3.2 EARLY WORK

Survivability was introduced as a function that defines more than one quantity rather than a single value measure by [25]. In their work, the function is suggested and applied to a simple ring network.

survivability for wireless systems is defined in [3]. They also study the effect of outages on users, the fix time and way to improve the survivability of the system. More light is focused on survivability through the work of [2] that defines the term and detail disaster avoidance in optical networks.

Some early researchers went through the effort of making the early definition of survivability and it was their voices that started to attract attention to the subject and its importance. One of the work discuss the importance of survivability in the future [26].

3.3 PRE-DISASTER STUDIES

3.3.1 Disaster monitoring, detection and prevention

The paper [5] presents a method for monitoring connection oriented networks (ATM, IP) through both scheduled and unscheduled events in case any may trigger network disaster caused by control massage storm. In order to provide a continuous monitoring to the system in question and report the event along with the degree of how critical it proves to be in order to minimize report time. Enhancing survivability in harsh scenarios is the main issue described by [27], that suggests the use of Dynamic Source Routing for survivability enhancement in IP networks. Dynamic Source Routing is also used by [28] on survivability where Dynamic Source Routing is used to enhance survivability in connection oriented networks (MPLS, ATM).

On the other hand, [29] presents survivability scheme for IP/GMPLS (optical) networks, that reduces recovery time by optimizing detecting time, notification time and wait time.

Mobile networks' survivability has its share of attention, an approach to detect critical links (that are likely to fail and cause partitioning) in wireless Ad Hoc is proposed by [30], the paper also presents a technique to delay if not prevent the failure from happening.

Also in mobile networks the forced hand over strategy is presented by[6] in order to increase survivability.

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3.3.2 Modeling and simulation

On the other hand other researchers focus failure analyses in what is generally called pre-failure studies. Many examples can be produced here but we chose to focus on the work presented by four teams of researchers

A model is presented by [4] to anticipate the additional network capacity needed to overcome the impact of large-scale regional failures that are caused by natural disasters. The research team developed a model for one of the European networks and has applied failure scenarios that include the probability of triple failure or more that happen in the same time and are related geographically as the case in failures caused by natural disasters. But the paper neglects the scenarios that cause network partitioning. The modeled restoration technique is the standard for MPLS (Multiprotocol Label Switching).

Another model is presented in [31] this model focus on strategy selection by using the Fuzzy Matrix Game to minimize network loss of services and maximize the probability of services survivability in the cases of hacker attacks on networks presents. The main idea is to view the hacker-system relation as a game, where for every action the hacker employ there exist a strategy that the system deploys. They use the Fuzzy Matrix Game to choose the strategy, In other words increase survivability during malicious acts.

SI (Survivability Index) is presented in [6] as a measure to identify survivability in those networks along with a mathematical model to prove the measure's efficiency.

The paper [7] describes a quantitative method based on grey relation analysis is presented to improve survivability probability during security attacks.

4. MODELING SURVIVABILITY OF COMPUTER NETWORK IN SOUTHEAST ASIA

4.1. NATURAL DISASTERS IN SOUTHEAST ASIA

It is clear that when it comes to future disasters, Southeast Asia is likely to be subject to a lot of disasters' activities. The map in Figure 2 represents the region to climate change in comparison to the rest of the world, dark areas are more vulnerable to climate changes, lighter areas are less vulnerable. Some countries (such as the Philippines) are more vulnerable mostly because of geographical reasons. The poverty rate in some of the countries in the region makes the population more affected by impact of disasters especially due to the weak basic structures that can be a major obstacle for relief efforts after disaster hits. The ADPC overview on disaster management [32] declares that countries with weak economy and high poverty rates are more effected by disasters, and that the population there has lower ability to cope with disasters' impacts.

It is clear from Figure 2 that countries like Malaysia are almost safe from the expected environmental change impact on the region. If vulnerability is measured regionally as shown in Figure (3) then countries like Malaysia is not vulnerable at all. This does not mean that no indirect effects will be witnessed. Moreover to overcome the effect of regional disaster a regional plan need to be developed and all regional countries need to collaborate in order to carry out the plan, the less vulnerable areas can play major role during crisis in the region.

4.2. COMPUTER NETWORK INFRASTRUCTURE IN SOUTHEAST ASIA

In order to study the correlation between networks and disasters, first one should take a look at the infrastructure of the network as well as the expectation of disasters in the targeted area.

Southeast Asia's networks are of some importance due to the geographical importance of the region, the fact that makes the network in this region more like a connection among continents and among other regions.

The map shown in Figure 4 [33] describes the IP networks in the region. The figure shows clearly the crucial connective role for the region's networks among east, west and far west.

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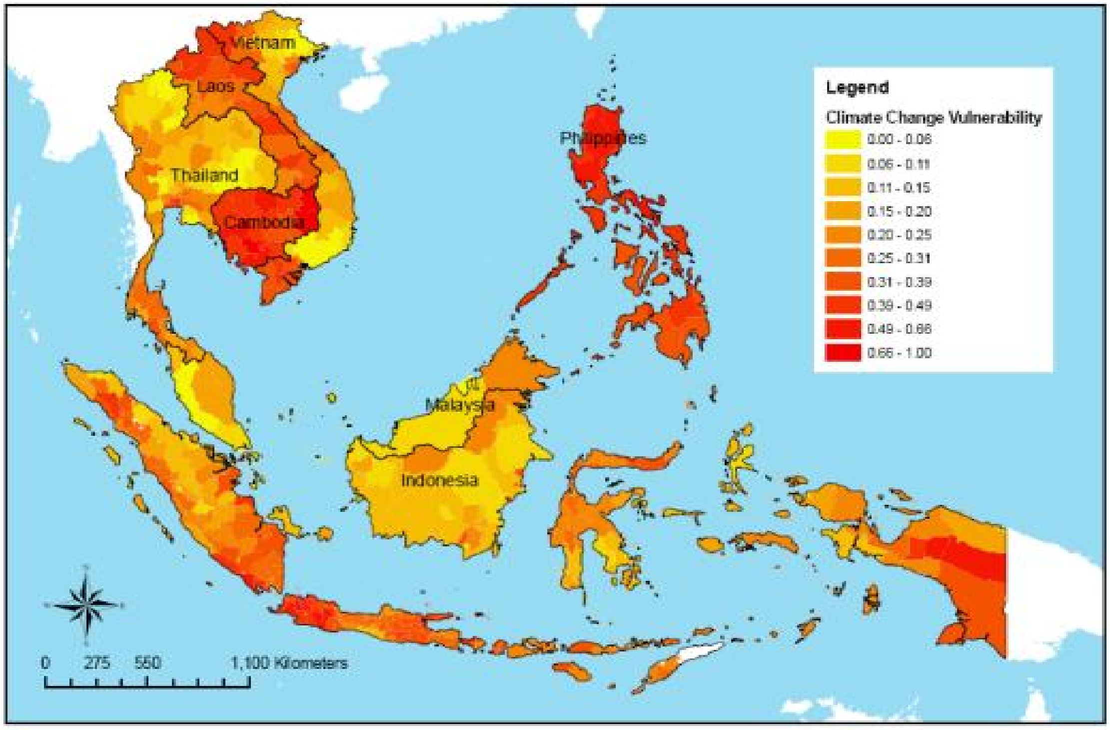

Figure 2. Climate changes vulnerability map of Southeast Asia [34]

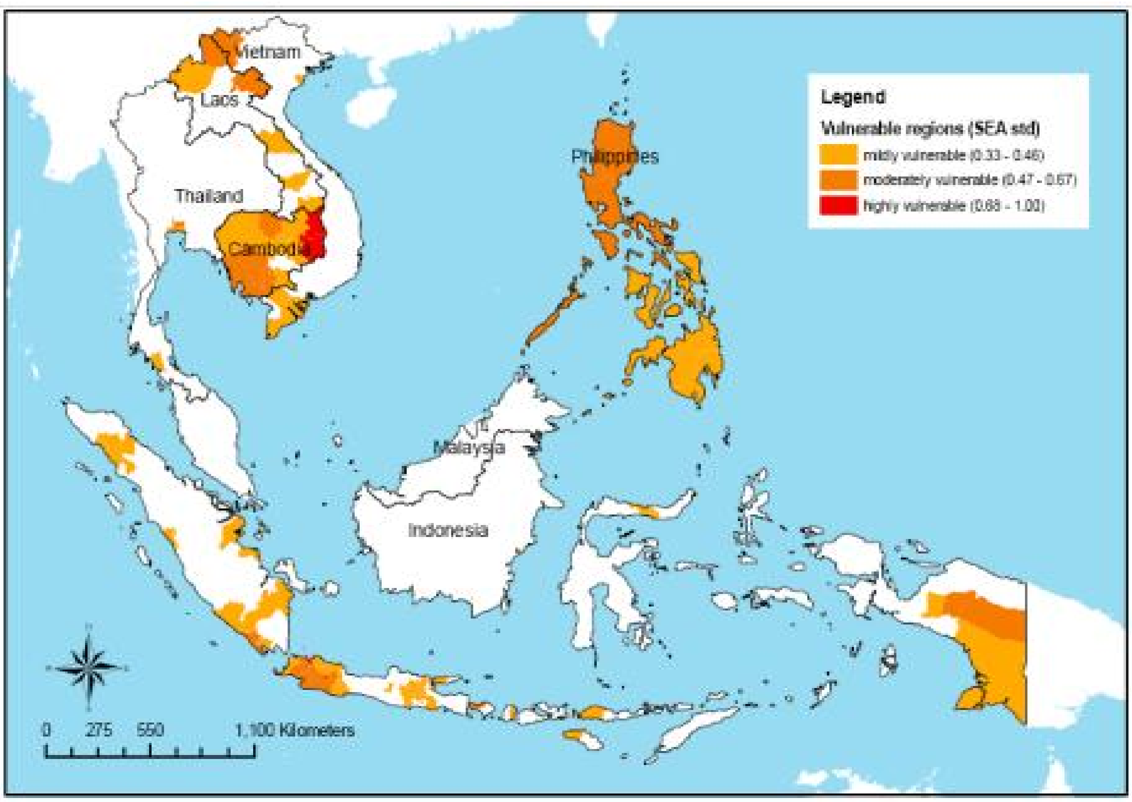

Figure 3. Most vulnerable areas Southeast Asia (regional standards) [34]

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4.3 INITIAL MODEL

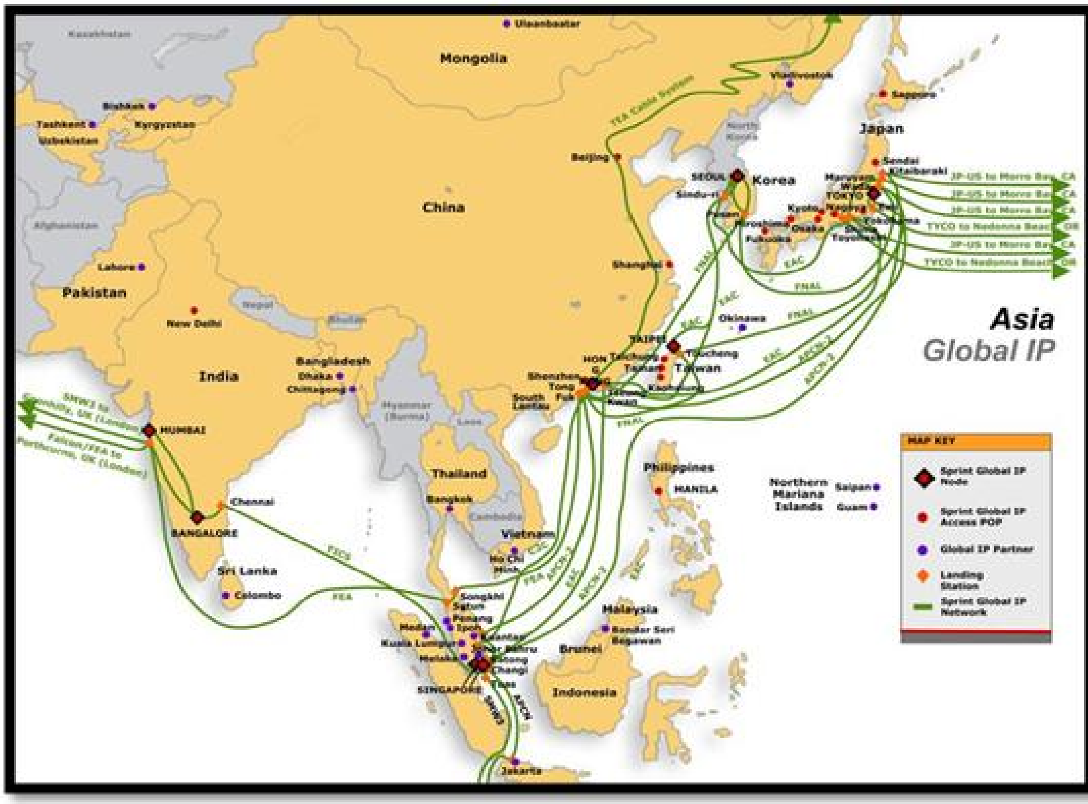

Figure 4. Global IP networks in Asia

4.3.1 Bassiri's model

Bassiri and Heydari describe in [4] a large scale regional failure model to examine the applicability and performance of dynamic restoration methods in large scale failure scenarios. The purpose of the model is to examine the achievable restoration times and assesses the capacity requirements in these cases.

In the model, the network is represented as links (modeled as direct lines) and nodes (modeled as single points), the network topology is defined by an adjacency matrix A in which the value of "1" is assigned if a link between two nodes "i and j" exists and a "zero" if not. While C is the coordination vector that determines the geographical location of each node in respect to a pre-defined centre Figure 5.The network traffic is identified by the demand matrix D. An epicenter for the regional failure is defined with the range R. According to the model if all nodes and links within R fail then all traffic from/to those network elements are lost and therefore a new topology matrix and demand matrix are defined in accordance with the changes resulting from the failure.

The model was tested on the European network COST-239 as shown in Figure 6. In this case, random end-to-end demand matrices were generated and the demand between each pair of nodes was randomly chosen from a number in the range of [1, Dmax].

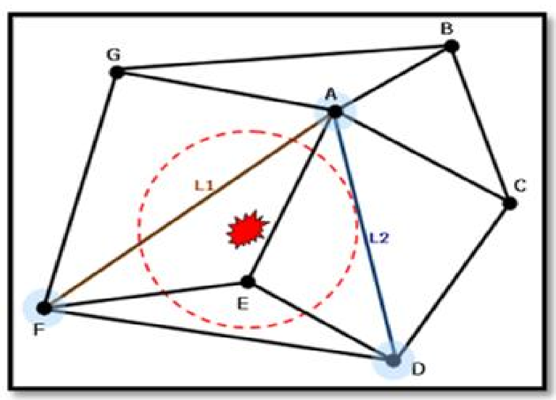

Figure 5. Bassiri's Model [4]

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The value of Dmax was used as a simulation parameter and is changed from "one" to "9" where a smaller the number indicates higher level of homogeneous demand in the network. From this study, it was found that an impact range greater than (264 Kilometers) may cause network partitioning therefore R was set bellow that (50, 150 and 250) for the failure scenarios.

A total of 297 simulation scenarios were performed and the respective changes in network traffic and estimated response times were calculated. The researchers claim that the same model is applicable to North America, and preliminary results for the Labnet03 network were presented in the same paper.

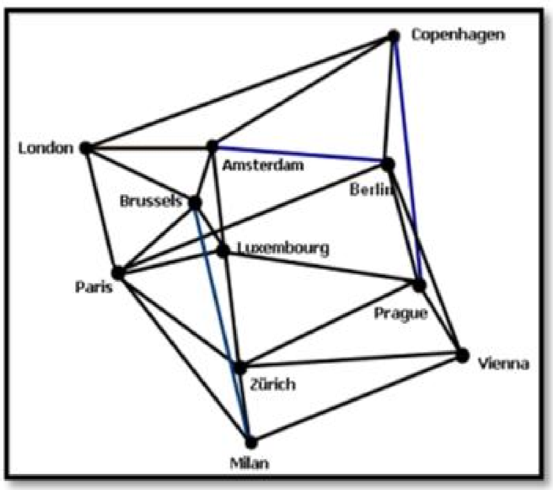

Figure 6. The COST-239 Network [4]

This work addresses a number of important issues in large scale failure and restoration, which suggests that failures with a common geographical region (geographically related failures) are an important problem in present time. The most important thing that has been established is that certain characteristics of large scale failure scenarios (which are special cases of multiple-failure scenarios) could simplify their modeling and simulation, along with presenting a method to model the regional failures.

On the other hand by assuming that an impacted area can take a predefined shape (e.g.: circle or square) is hardly realistic, unless the failure is caused by a nuclear attack which the paper listed as one of the possible causes of such failure. However, there is no indication that it is the only cause for this model. Another issue is the assumption that all nodes and links in the impact range fail may simplify the work, but again in some cases such as tsunami waves, this is not always true. Last but not least the possibility of network partitioning need to be addressed in situations where no end to end network flow is feasible, it that does not mean that such case cannot be addressed although it may consume a lot of recourses.

4.3.2 Differences between the two models

Based on the model described in the previous section, we have developed a new model that is focusing on a different aspect. The main difference is the main goal of the models. In the Bassiri's Model the main focus is for the ability of the network to survive a large scale failure caused by disasters. On the other hand in our model the main goal is to evaluate the changes in network traffic for a particular part of the network (Malaysia) that is driven by large scale failures by other parts of the network. In other words, while the first model studies the survivability of the remaining parts of the network after other parts suffer major failures, the proposed model studies the impact of different regional failures on a predefined part of the network.

While Bassiri's Model does not consider the cases of network partitioning because there is no end to end network traffic, the proposed model highlights the importance of the network that are inaccessible because. This is because; the main focus is on the changes that take place in one part of the network even when some other parts are isolated.

Another difference is that the first model is used to calculate the response time, which is not part of the objectives as our research aims to develop a strategy that can deal with disaster oriented regional failures monitor changes in the traffic of a network.

Although some disasters' reasons such as WMD (Weapons of Mass Destruction) attacks have a relatively similar impact on different regions, other type of disasters will mostly have different impact. Since the geographical nature of South East Asia is different from other regions such as Europe and North America where most of the region is landed region when compared to SEA that is mostly surrounded by big masses of water from more than one side, the impact the disaster as well as the trigger of incidence are completely different. Therefore, the SEA region faces different disasters caused by different causes resulting in different outcome. Due to the special nature of SEA, some points need to be considered when addressing this region such as:

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(i) Having large areas of the region covered with water forces parts of the networks' backbone being installed in water. This allows the possibility of having multiple link failures that does not occur simultaneously with node failures.

(ii) Simplified assumptions such as shaping the affected area are not always applicable due to the fact that different disasters effect differently. Therefore we need to address each disaster properly based on the range of the impact.

4.3.3 The proposed model for south east asia

The model that we have developed is a graphical representation that aims to simulate the impact of a regional accidental disaster can have on a computer network. It focuses on finding the changes in the network topology and how that can affect the network traffic in another part of the network outside the impact zone.

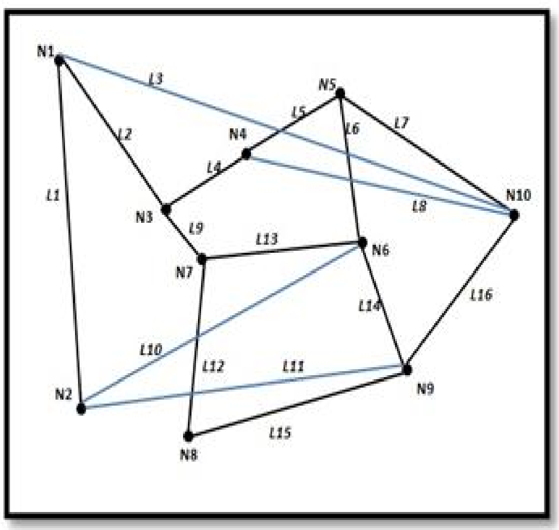

Figure 7. Proposed Model

The network is represented as nodes modeled as dots (N_1, N_2, N_3…) and links modeled as lines between these nodes (L_1, L_2, L_3…). A matrix A represents the relation between the network components (the network topology) if a link L_z exists between two nodes N_i and N_j, then A_{ij} will be assigned the value "1" if not it will be assigned the value "0" as shown in Figure 7. The network traffic is represented by a matrix S, the value of S_{ij} represents the network traffic between the two nodes N_i and N_j. The targeted node is considered the origin coordination for all other nodes.

When an impact or event takes place it is given a range depending on the type and magnitude of that event along with the coordinates for the center for that event (imp-centre). All nodes and links within the range distance from the imp-centre will be affected but will not necessarily fail. If a node and all its links are within the impact range from the imp-centre then the node and all its links will fail and are no longer able of exchanging network traffic, but if at least one of the node's link is still active, then the node may survive and may be capable of exchanging some traffic.

When a node fail it is no longer able to exchange network traffic and all traffic with this node as its original or destination point will be lost. Figure (8) shows one scenario for applying a disaster impact on the same network in Figure (7), the failing adjacent node in this scenario is N3 and the links L_2, L_4, L_9 will therefore fail. Nevertheless, link L3 may or may not survive depending on the type of disaster and as a result, node N1 will still be able to process some network traffic because it is not in the impact zone and it still have at least one active link (L1). The network topology will have to be altered by removing the failed components, therefore matrix A will also need to be altered and as a consequence the matrix S will also be changed. In other word a new network will emerge, this network represents the survived network and the network traffic for pre-defined node can be calculated.

The previous model uses the shortest path first algorithm (used in TCP/IP) for rerouting the network traffic. However, in the model that we are proposing, we choose Constrained Shortest Path First (CSPF) that is used in Multiprotocol Label Switching (MPLS). The reason behind this is that such large-scale regional networks mainly employ the later protocol over TCP/IP network in routing. On top of this, the proposed model considers the event when there is no end to end network as a possible event. This is due to the fact that even if an entire part of the network is unreachable, it is still possible to determine the traffic in the node of interest as long as this targeted node is not part of the unreachable part and during such event all the partitioned part is considered and treated as failed part.

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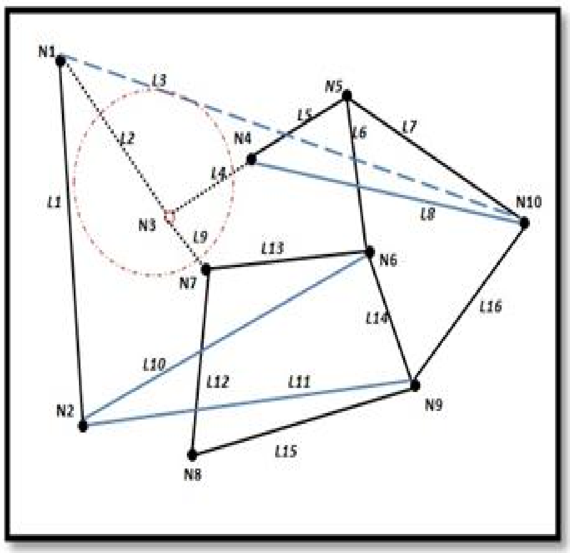

Figure 8. Survived Network

The ever changing nature of disasters and the new challenges that it brings along makes it necessary to address the possibility of some disaster acting as a trigger point to another. Therefore, it does not matter if the second disaster is another natural disaster (such as tsunamis caused by earlier earthquake) or technological disaster (major network failure or nuclear leakage caused by earlier natural disaster) [8], such scenarios need to be deal with. This model will be capable of addressing such cases by reapplying the same process to the new network emerging after the first disaster impact is evaluated.

5. CONCLUSION

Disasters have been and will always be a challenge to the society that can inflect a great damage to the social way of life. It is a challenge that is changing throughout time that requires planning and sufficient preparation. As networks have become intricately intertwined with our everyday life, it is crucial for networks to be protected in time of disasters as an important tool in disasters mitigation, rescues operation and rehabilitation process.

Both the geographical location and the vulnerability (in some countries) of some of South East Asia make disasters a serious threat that needed careful planning.

Although the main objective of this model is to study the change in network traffic of a large–scale failure, nevertheless this is considered as the first step and the beginning of our work, in the future we aim to further analyze and addresses disasters' impact on the region such as:

- Developing strategies for managing networks in time of disasters that can be a part of more general disaster plan for the country and the region.
- Forecasting the crucial additional resources to maintain/ achieve some performance goal during time of crises.
- Facilitate in planning the important assets for unharmed parts that can serve as mitigation centers for crises areas, these assets might prove to be crucial for logistic management

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