VLTNet: 위치 신뢰도 가중 네트워크 토폴로지 시각화 프레임워크

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VLTNet: A framework for Visualizing location trustiness weighted Network Topology

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요 약

In the aspect of effective and efficient network management, it is important for network administrators to obtain the reliability of network components on time, especially in the case of disasters. In this paper, we propose a novel system, VLTNet, which is a framework for visualizing the topology of a computer network with trustiness of location weighted on the links and switches. It displays reliability of the geographical locations by analyzing the disaster events. The system allows a network administrator to make a network topology with the switches and links on the web map. Visualizing the trustiness of location for the switches and links of the network infrastructure provides a view for users to detect easily network failures in the case of disasters. The system will automatically update the view whenever new switches, links, or disaster information become available in the database. This paper discusses (1) the method of calculating trustiness of location based on multimodal information of natural disaster events, (2) the architecture of VLTNet, and (3) the primary implementation of VLTNet.

1. Introduction

Nowadays, the natural disasters such as an earthquake or typhoon could occur anytime, and anywhere. During disaster events happen, the network communication plays an important role for diffusing information for disaster notification systems. However, it may get catastrophic impacts such as link failures. Therefore, developing a system visualization the networks topology with the impact of disaster events on the switches and links is particularly evident for detecting and recovering the network failures, which are most commonly used in practice.

One factor that is really important in location-based applications such as disaster warning systems and network controllers is trustiness of location. The estimation the trustiness of location in disaster situations can help detect the network links or switches in failure region, where has a low trusted value.

There are several researchers who worked on the trustworthiness of information. The dynamic source routing (DSR) is modified in [1] so that the path with the highest trust is selected among those leading to the desired destination, instead of selecting the shortest path, to enhance security. To apply for wireless sensor networks [2] focused on the way that trust information is combined with location-based routing protocols.

There have been a number of studies for visualizing the topology of a computer network to monitoring and analysis, primarily for monitoring network health and performance [3], [4], [5]. However, there are still no studies focused on visualizing the impact of disaster events on the network infrastructure, which is important for network administrators to obtain the reliability of network components on time.

In this paper, we propose a novel system, VLTNet for visualizing network topology with location trustiness weighted. Our work makes the following contributions:
- First, we build the *monitoring agents* for real-time collecting disaster information from the disaster public information such as United States Geological Survey (USGS).
- Second, we propose a method for calculating the

trustiness of a location based on multimodal information. This work combined both disaster information and sensor data is presented, which put a weight factor on each kind of trust value.

● Third, we develop a web map for visualizing location trustiness weighted on the network topology.

● We also design a module for management a network topology in the web interface. This allows users to make a network topology with the switches/links on the web map.

The rest of this paper is organized as follows. Section 2 presents our approaches of calculating trustiness of location: one is based on disaster information, another is based sensor data, and a combined approach of them. Section 3 takes into account the architecture of VLTNet. The implementation is presented in Section 4. Finally, Section 5 concludes the paper and discusses the future work.

2. Calculating Trustiness of Location

In this section, we describe an overview of calculating trustiness of location based on multimodal information, that we introduced in [6].

2.1 Trustiness of Location based on Disaster Information

To calculating trustiness of location, we first define a geo-mapping matrix (GMM), then calculate the impact of an earthquake event based on the magnitude and location.

A GMM is defined by a matrix which covers the earth, the row indicates latitude from -90 degree to 90 degree and the column indicates longitude from -180 to +180. That is a set of locations $L = \left[L_{i,j} \right]_{n \times m}$, where $L_{i,j}$ is a location that shows starting position of each cell on matrix. A cell of this matrix has a size $c \times c$ with c can be a real number describing the length by kilometer.

We define a trustiness matrix $T = \left[T_{i,j} \right]_{n \times m}$ which describes the impact of earthquake events on matrix L, where $T_{i,j}$ denotes the trustiness of location for an earthquake event and it is any real number ranging from 0 (no trust) to 1 (full trust). The impact of earthquake e is defined by a trustiness matrix $T^e = \left[T_{i,j} \right]_{K \times K}$, where K is the size of the matrix T^e and $T^e \subset T$. We formulate the influence of an earthquake on each cell of T^e as follows:

$$T_i = \begin{cases} 1 - \dfrac{M}{\delta} & \text{if } i = 1 \\ T_{i-1} + \dfrac{M}{\delta \times R} & \text{if } i > 1 \end{cases} \qquad (1)$$

where i is a number of integer that shows the distance by cells from epicenter cell (i=1) to R on the GMM, R

is a number of integer and $R = \dfrac{K}{2} + 1$; δ is a threshold of magnitude to set trustiness value equals 0 ($M \geq \delta$). Here, $L_{i,j}$ can be affected by a set of the earthquakes $e = \left\{ e_1, e_2, .., e_n \right\}$. Our approach based on averaging trustiness value of that cell on the matrix as follows:

$$T_{i,j}^n = \frac{1}{n} \sum_{k=1}^{n} T_{i,j}^{k-1} \qquad (2)$$

where $T_{i,j}^n$ is the trustiness of location at $L_{i,j}$ after earthquake event e_n happened.

2.2 Calculating Trustiness of Location by using Sensor Data

In this approach, we assume several cells on the GMM used in some kinds of sensor such as temperature sensors and smoke sensors. Let $s = \left\{ s_1, s_2, .., s_n \right\}$ is a set kind of sensor on a cell. Each kind of sensor is assigned with a weighting that indicates its degree of influence on trustiness of location. We define $w = \left\{ w_1, w_2, .., w_n \right\}$ is a set of weight corresponding to s. For each s_i in a cell, we use m_i sensor(s). Let s_{ij} is the sensor jth in s_i, x_{ij} is trustiness of location from sensor s_{ij} which is calculated by using the equations in [6]. We formulate for calculating trustiness of location based on sensor data as follows:

$$f_{(x)} = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{m_i} \sum_{j=1}^{m_i} w_i x_{ij} \qquad (3)$$

2.3 Combined Approach

The combination of these two approaches can make reliability the trustiness of location. To do this, we define T_D is the trustiness of location which is calculated based on disaster information such as earthquake events, T_S is the trustiness of location using sensor-based ($T_S = f_{(x)}$), see Equation 3. Now, the final trustiness of location T_L on a cell is defined as follows:

$$T_L = w_D T_D + w_S T_S \qquad (4)$$

where w_D is the weight for trustiness of location T_D, w_D is the weight for T_S and $w_D + w_S = 1.0$.

3. The Architecture of VLTNet

Our goal is to build a framework visualizing location trustiness weighted on the network topology. The system is designed to run online on the web environment. The VLTNet's overall architecture includes 6 mains components in three layers (as shown in

Figure 1).

3.1 Monitoring Agents

This component is to connect to the outside database and automatically gather disaster information from the public services or disaster sensors. This work is performed by sub-component *External Data Access*. In the latter, the data are extracted by *Data Converter to* select the necessary disaster information. For example, the system only extracted the essential earthquake information from USGS site, including magnitude, time, longitude, and latitude.
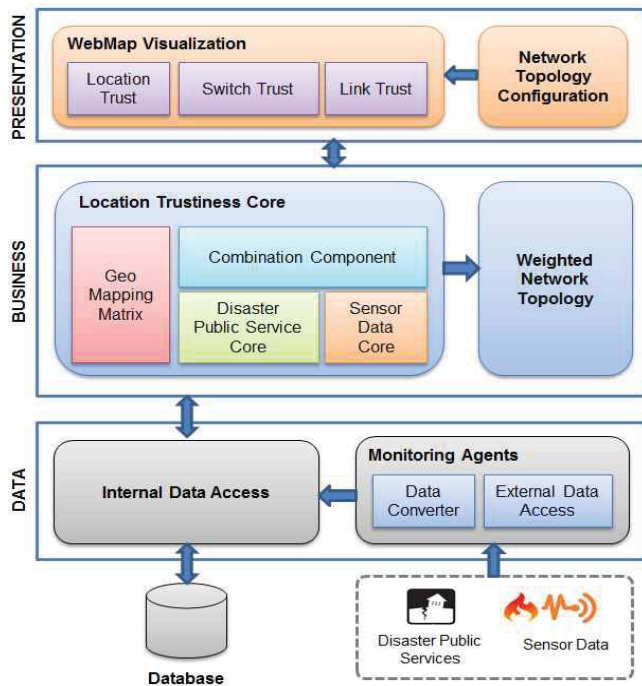

Figure 1. The architecture of VLTNet

3.2 Internal Data Access

This component makes the connection to the database server. In this component, we provide the stored procedures for querying database. The component communicates with *Monitoring Agents* component to retrieve the disaster information that is extracted from other services. It also communicates with other components in Business Layer to provide the information for calculating trustiness of location as well as the current network topology information.

3.3. Location Trustiness Core

This is an important component in VLTNet, which calculates the trustiness of location based on multimodal information from natural disasters. This component is implemented following the procedures shown in Section 2. Therefore, this component consists the module for defining a GMM, the *Disaster Public*

Service Core which is responsible for calculating trustiness of location based on data from other disaster public services, and the *Sensor Core* for processing sensor data. Besides that, another sub-component is *Combination Component* which provides the final trustiness of location based on the trusted value from both disaster information and sensor data. This component communicates with other components in Presentation Layer to provide trustiness of location for visualization and provides trusted value to Weighted Network Topology component.

3.4. Weighted Network Topology

The system maps the switches and links on the GMM, then assign each of them a weighted with a trusted value based on its location on the map. This work is performed in *Weighted Network Topology* component. The trusted value for each switch is the trustiness of location where it is located. For each link on the topology, the trusted value is assigned based on the averaging trusted value of the locations on the GMM in which a link crossed. To do this, we consider the problem of calculating the trusted value of a link L_i in the network topology. A link L_i in the network topology can be represented by a polyline. We treat a polyline as a single object, including component segments. Each line segment is identified by two points: source location and destination location. So, we can make the line y between two that points. Next, we consider the finding all cells in which the trustiness of location is less than 1.0 and the line y is crossing. Finally, the trusted value of L_i in the network topology is the averaging trustiness of location from all cells that link affected by the disaster events.

3.5. WebMap Visualization

The system provides a web map for visualizing the location trustiness weighted network topology. In this interface, it shows a network topology as a graph, in which each switch as a node, and each link between two switches as an edge. Especially, each of them is assigned a *location trustiness weighted*. Besides that, this interface shows the trustiness of locations of GMM, which are affected by disaster events. This work provides to users a view about the impact of disaster events on the affected regions.

3.6. Network Topology Configuration

This component also is a part of the web interface. It allows a network administrator can adjust the information of network topology such as adding the switches/links and setting IP address or position
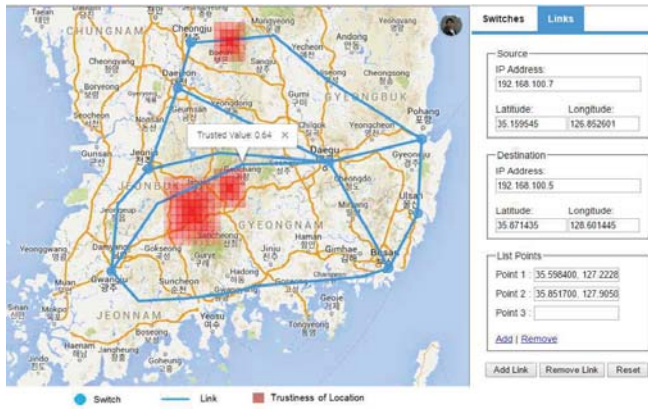
Figure 2. The main interface of VLTNet

switches/links on the map. The information of network topology is updated automatically into the database server and refresh the WebMap Visualization.

4. Implementation

We have implemented successfully VLTNet for visualizing location trustiness weighted network topology, in which trustiness of location is calculated based on earthquake information. For the sensor data, we will consider as the future work. Our framework is implemented as follows.

Java-based techniques are able to construct a program to automatically gather the earthquake information from the USGS site, in which data is stored in JSON format. We extracted the data with essential information, including magnitude, time, longitude and latitude. Then the data is stored in MySQL Database. Another Java program is implemented to calculating trustiness of location based on earthquake information. This program monitors the changing information on the database server to calculate trustiness of location, maps trusted value to switches/links. For visualizing trustiness of location and configuration network topology, we implemented a Web Map using C# language in .NET framework. To show the map and draw the switches/links we used the Google Map APIs.

Figure 2 illustrates an example of visualization a network topology by using our framework. This figure shows a network topology that the links are created by connecting a few switches located in different province/city of South Korea. In this example, we created three samples of the earthquake events. which is stored in JSON file like the structured that provided by USGS. Then, the system collects data, calculates, and displays the trustiness of location on the web. Here, whenever the user clicks on the link or switch, the system will show the information about trusted

value for their one.

5. Conclusion

We propose a novel system, VLTNet, which is a framework for visualizing the topology of a computer network with trustiness of location weighted on the links and switches. It displays reliability of the geographical locations by analyzing the disaster events. The system allows a network administrator to make a network topology with the switches and links on the web map. Our framework provides a view for network administrators to detect easily network failures in the case of disasters. In the future work, we will focus on other applications which can be applied the trustiness of location such as a disaster notification system.

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