A novel method to improve dependability of Wireless Communication System

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Abstract: *Adjusting frequency channels or device location played important role in improving Wireless Communication System (WCS). While focusing on flexible automated methods, researchers designed non-cooperated methods that did not allow WCSs to exchanges messages. But later on, the researchers used max − plus algebra and Petri net to invent cooperated methods. Later, leveraging model predictive control was used to improve WCSs by controlling dependability parameters to preserve all logical links. But the drawback of this approach is its inability to avoid the logical link explosion where the number of logical links increases sharply. In this article, the proposed method Killing the worst logical links (KWLWCS) assesses the logical links and removes the worst logical links in order to improve WCS.*

***Keywords**: Dependability, Wireless communication system, Critical Logical links, Machine leaning, Assessment*

1. Introduction

Information is transmitted using wires, cables or electrical conductors. But wireless communication can connect two or more devices and establish the communication without any of these. Its effective features are as follows.

- The distance between the communicating devices can be a few meters
- It can be used to establish the communication through the cell phones, cordless telephones, satellites, and so on
- It can be used for accessing internet
- It is used in implementing GPS units, door openers,
- It is used in implementing wireless input/output devices of computers

As the wireless communication does not require the physical connection, it has many advantages. It needs very small physical infrastructure. As a result, the cost associated with maintenance is reduced. The distance between the people does not affect their communication in wireless communication. Wireless communication enables people to communicate regardless of their location. Wireless communication devices are very easy to use. Accessibility and network connectivity have been improved in terms of accuracy and speed. Wireless communication makes use of the following waves.

- ➢ Radio-frequency
- ➢ Infrared
- ➢ Microwave
- ➢ Other types of electromagnetic or acoustic

Examples for Wireless devices are:

- Cell phones
- Two-way radios
- Remote garage-door openers
- Television remote controls
- GPS receivers
- Wireless modems,
- Microwave transmitters
- Satellites

The logical links are used to establish the communication between the wireless. Each logical link is associated with a set of dependability parameters based on its requirements [1]. In this article, the proposed method assesses the logical links and kills the worst logical links in order to improve WCS.

2. The Proposed Method

Fig. 1 specifies the phases in critical link assessment (CLA). The data from WCSs is measured initially. Labelling the raw data is done using a rule-based labelling. Features are extracted using a deep autoencoder network. The link correlation coefficient is calculated using a fully connected neural network. Finally, the link correlation coefficients are sorted to identify the worst links.

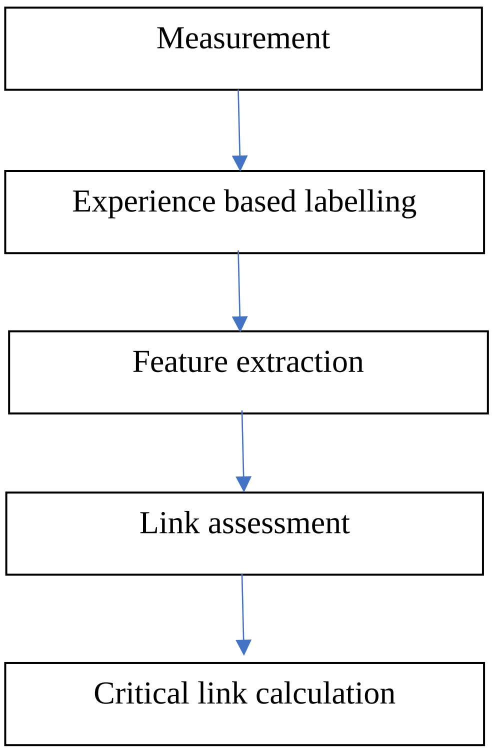

Figure 1: The steps in the proposed method Killing the worst logical links (KWLWCS)

The logical links are used to establish the communication between wireless devices. These logical links have the following dependability parameters.

- Transmission time

- Update time
- Lost message state
- Consecutive message loss
- Lost message ratio

The above parameters are measured using measurement devices. The data collected at each wireless device is stored at a five-dimension vector. The data collected will be cleared and normalized using a min-max normalization. In the experience-based labelling, a correlation coefficient (CC) in the range [0, 1] is used to specify how two logical links are correlated. The following classes are defined.

- Class A contains CC of the logical link with itself
- Class B contains CC of the logical link with other logical links in the same wireless communication system
- Class C contains CC of the logical link with the logical links in other wireless communication system

The feature extraction network returns a high dimensional matrix for each logical link. The high dimensional matrix might have redundant information. To avoid this issue, the same network is executed again to get a low dimensional matrix for each logical link. In link assessment, the maximum average correlation coefficient is found. As the link assessment returns maximum average correlation coefficient, the coefficients gets ordered so that we could stop a logical link that has least coefficient.

3. Experiments & Results

We used ifak's Multiface[2, 3] to simulate the behaviour of wireless applications by choosing the distance between the deivces and the number of logical links. We have defined three test cases such that each test case has three logical links and the transfer interval is 0.l25s. The distance between the devices in each test case is specified in Table 1. We evaluated a wireless communication system Bluetooth Low Energy [4].

Table 1: Distance between devices in each test case

Test Case	Distance between the devices
TC-1	50 m
TC-2	100m
TC-3	150m

The correlation coefficients (A, B, C) are initially set for the three wireless communication systems as follows.

- A_i is set to 1 for each i^{th} wireless communication system
- $B_1 = 0.7$, $B_2 = 0.5$, $B_3 = 0.2$
- $C_1 = 0$, $C_2 = 0$, $C_3 = 0$

Table 2: Average Correlation Coefficients between the links with respect to change in the distance

Distance		L1	L2	L3	CLA
50m	L1	0.9621	0.5923	0.6936	0.7493
	L2	0.6377	0.8903	0.6841	0.7373
	L3	0.6803	0.6927	0.9967	**0.7899**
100m	L1	0.9228	0.6343	0.5276	**0.6949**
	L2	0.6234	0.9738	0.3985	0.6652
	L3	0.6017	0.5294	0.8899	0.6736
150m	L1	0.9804	0.2993	0.2988	0.5261
	L2	0.3982	0.9098	0.2105	0.5061
	L3	0.4241	0.2995	0.9888	**0.5708**

We collect 9990 features of each logical link of each wireless communication system. In each wireless communication system nine pairs of logical links are there. Among 2700 labelled data, the training phase is conducted using 80% data and the remaining data is used for testing. For conducting our experiments, we used PC with a 2.8 GHz 3-core CPU, 6GB GPU of NVIDIA GeForce GTX 1060, with RAM of 16GB. In Table 2, CLA specifies the average coefficient with itself and other links. When the distance is 50m, L3 gets the biggest value for CLA, so it is to be stopped. When the distance is 100m, L1 gets the biggest value and so it is to be stopped. When the distance is 150m, L3 is to be stopped as it has biggest CLA. The biggest CLAs in each wireless communication system are specified in bold font.

4. Conclusion & future work

In this paper, we proposed an automated dependability control solution to remove the worst logical link. The proposed method resolves the logical link explosion issue. The proposed approach has steps of measurement, experience-based labelling, feature extraction, link assessment, and critical link calculation. In further work, we will study how the proposed method deals with increasing measurement data and the effect of the α, β, and γ. In addition to this, we want to investigate whether the nature-inspired algorithm Social Spider Optimization (SSO) can be used to more effectively find the worst link in each wireless communication system.

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