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Real Time Traffic Control System Using Wavelet Neural Networks Signal for Wireless Communication Technology of Future High Speed Railways Performance in Thailand with Intelligent Transportation Systems

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Abstract: This paper presents a real time traffic control system strategy by applying Wavelet Neural Networks (WNN) transform signal processing for wireless communication technologies of future high speed railways performance in Bangkok, Thailand with intelligent transportation systems. Innovations to address challenges emanating from railway transportation traffic system congestion. For Improving economies create more railways owners resulting in increased automobile manufacturing. Commuting time negatively impacts working hours. The economy will take a beating creating a vicious ecology cycle. But also a fast transportation alternative to air travel or regular passenger rail services. Providing these benefits would not be possible without the tremendous growth and prevalence for using wireless communication technologies. The wavelet transform has been successfully applied in many signal processing. The technique is based by using the absolute sum value of coefficients in multi resolution signal decomposition based on the discrete wavelet transform signal for data driven intelligent transportation systems. This survey provides an overview of the current state-of-the-art and future trends for wireless technologies aiming to realize the concept of High Speed Railway (HSR) communication services [1]. Our goal is to highlight the challenges for these technologies, including GSM-R, Wi-Fi, WIMAX, LTE-R, RoF, LCX & Cognitive Radio, the offered solutions, their performance, and other related issues. This paper studies these models to infer that with traffic railways signal control systems are supported. Simulation results of control system provided traffic information for course correction. It is proposed to integrate traffic system data with the traffic signal. However, with the advances in communication systems, such as LTE, 4G and cognitive radios, it is becoming possible for system designers to offer rich services to passengers while also providing support for enhanced train control operations such as positive train control.

Keywords: Traffic control system, wavelet transform, signal processing, railway, intelligent transportation

1. INTRODUCTION

Now, intelligent transportation systems (ITS) have evolved significantly in recent years. Modern ITS are driven by data collected from multiple sources which is processed to provide new services to the stakeholders. In a recent survey paper, Zhang *et al.* [2] describe how conventional intelligent transportation systems have transformed into data-driven ITS, with collecting large amount of data from various sources and processing the data into useful information technology, data-driven ITS which can provide new services.

The intelligent transportation control system strategy is a complex industrial management system, and railway control network to reduce the overall economics cost efficiency and remove the negative effects on the sugar production system.

High Speed Railway (HSR) provides its customers not safety, security, to comfort and on-time commuting, but also a fast transportation alternative to air travel or regular passenger rail services. Providing these benefits would not be possible without the tremendous growth and prevalence of wireless communication technologies. Due to advances for wireless communication systems, both trains and passengers are connected through high speed wireless networks to the Internet, data centers and railroad control centers [2]. A train is considered to be a high speed train, if it is capable of achieving a speed of more than 250 km/hr. At that speed it is a challenging task to maintain for a stable communication networks between Base Station (BS) and train due to propagation and channel effects, cell handovers, and more. Proposed efficient to intelligent traffic control system by applying WNN transform signal processing with using wireless communication technology of high speed railways, train control systems are supported. It is becoming possible for system designers to offer rich services to passengers.

2. RESEARCH OBJECTIVES

2.1 To increases the safety and security for passenger intelligent transportation in traveling by the high speed train or railway performance in the area of domestic and international transportation system.

2.2 Focusing to transport business, this research aims to increases the advantage and economic efficiency, for both in the level of microeconomics and macroeconomics, to the public and private enterprises due to traffic signal control systems strategy applying Wavelet Neural Networks transform signal processing for safety and security in high speed railways performance.

2.3 To enhance of the international collaboration and cooperation between Thailand and the dialogue partners, such as the Republic of Korea, in developing advance technology for a real time traffic control system strategy to eliminates any problem in high speed railways for passenger transportation.

3. COMMUNICATION REQUIREMENTS IN HIGH SPEED RAILWAYS

Broadband access and reliable data communication channels have become an imperative part of HSR. Train operations, control, diagnostics [1], and highly depend on communications, when they are in communication with train control and dispatch centers, signaling zones, level crossings, stations and even provide of wireless communication among railcars and trackside equipment. This real-time traffic control system of communication does not require a significant amount of bandwidth or data rate [1]. But robust and reliable communications system is paramount for train operations management. Advanced communication systems often are employed to mitigate the potential for human errors. Train-related traffic provides services for train control, signaling, and the train-focused traffic is higher priority [2], due to because protecting the integrity and delivery of this traffic control system is more important than high speed railway performance, are infeasible for the control plane traffic system, but provide very high capacity for user plane of traffic control. The wireless communication network architecture for high speed rail resembles a tree topology as shown in Fig. 1 [1], where service providers are situated at the top of the tree, with representing the core network facilities.

4. EVOLUTION & TRENDS OF WIRELESS COMMUNICATION IN THE HSR [1]

Train-to-ground signal communication has been an important focus in the research around HSR, for due to its high speed and the complications signal of wireless communication systems resulting from it. Traditional communication methods could not support high speed railway deployments due to high train speeds, special track systems and installations are needed, is such as maglev and viaducts, with this drastic change in infrastructure, a resulting change in communication infrastructure was necessary. Wireless communication network are perhaps the most critical element in the global information of wireless mobile communication to make railway performance operations safer passengers. The authors therefore propose handling the real control for plane traffic over macro cells and resource intensive user plane traffic control. Providing Internet access on trains ensure broadband links between train and ground.

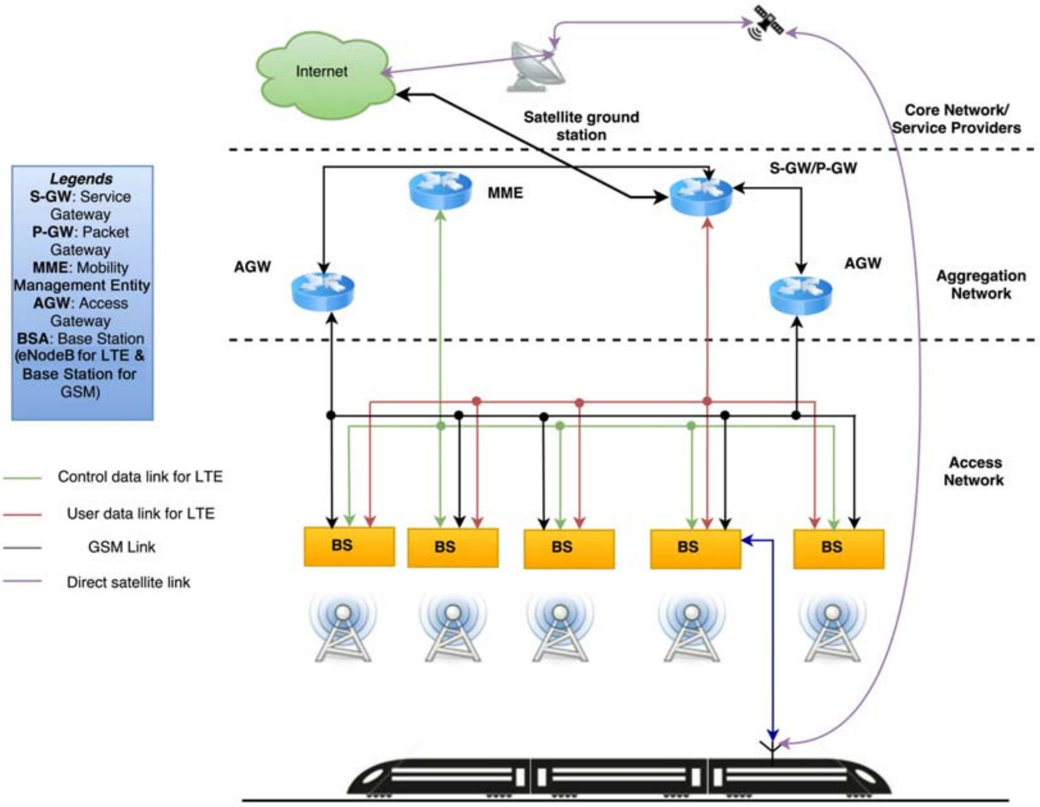

Fig. 1 The wireless communication network architecture for high speed railway performance [1]

The European Train Control System (ETCS) was the first to study this problem in detail and endeavored to resolve it by having a standard digital communication method for all trains in Europe. At that real time, for different analog train-to-ground communication systems existed in Europe and were consequently all replaced by ETCS, and because the technologies did not adequately support these high train speeds.

There now exists a variety of standards of train speed control signal communication, such as systems include Communication Based Train Control System (CBTCS), Advanced Train Control System (ATCS), Command Control and Communication Systems (CCCS) [1], and The Incremental Train Control System (ITCS), Positive Train Control (PTC), for as well as the aforementioned ETCS. The access network system is comprised of the trackside infrastructure for train-to-ground with signal communication.

The ETCS defines transmission characteristics for the network system with the follow parameters [1]:

1. Received signal power
2. End to end delay and data rate
3. Probability of loss of connection
4. Maximum break during handover
5. Connection establishment delay or call set up time;
6. Call establishment failure probability.

5. DEPLOYMENT ARCHITECTURES FOR DATA DRIVEN ITS

In Fig. 2 shows a typical three tier web-based deployment architecture used by conventional from data driven intelligent transportation systems [2]. Tier-1 or the front end servers consists of the web servers, tier-2 consists of application servers and tier-3 consists of data-base servers[2]. In Fig. 4 shows a cloud deployment architecture used in our proposed network system, this deployment architecture, tier-1 consists of the web servers and load balancers, but tier-2 consists of application servers and tier-3 consists of a cloud based distributed batch signal processing for infrastructure such as Hadoop variable. Compute intensive tasks such as data processing are formulated as MapReduce jobs which are executed on Hadoop. This deployment is suitable for massive scale data analysis. Data is stored in a cloud based distributed storage as Hadoop Distributed File System (HDFS). The advantages of cloud based architecture shown in Fig. 4**.**

5.1 Rapid Elasticity

Cloud-based deployment architecture leverages the dynamic scaling capabilities of computing clouds. Two types of scaling options networks are available for the cloud-based deployment.

5.2 Massive Data Analysis

Cloud-based distributed batch of signal processing infrastructure such as Hadoop allows processing large scale data [2]. Hadoop is well suited for location and sensor data analysis. The HDFS allow storing large files as multiple blocks, are replicated on multiple nodes data to provide reliability. The scale of location and sensor data is large that it is not possible to fit the data analysis on a single machine's disk. The HDFS not only provides reliable storage for large amount of used data, but also allows parallel signal data communication on machines in a cluster, and providing Internet access on board trains ensure broadband links between train and ground.

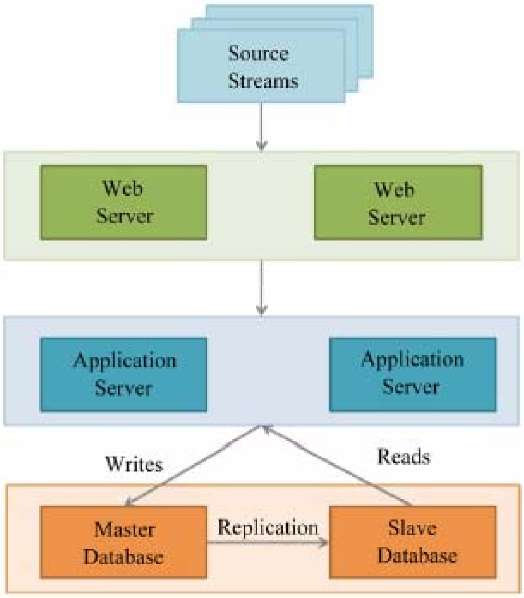

Fig. 2 Three-tier web-based architecture used conventional data driven intelligent transportation system.

Fig. 3 Future high speed railways to transport business for passengers with intelligent transportation, Bangkok, in Thailand

5.3 Ease of Programming

Programming models used by cloud-based distributed batch processing infrastructures such as Hadoop allow parallel processing of data. For example, with Hadoop, the location and sensor data analysis algorithms can be implemented as MapReduce jobs. Scaling out the computation on a large number of machines in a cluster is simple with Hadoop. The same computation that runs on a single machine can be scaled to a cluster of machines with few configuration changes in the program.

5.4 Flexibility in Data Analysis

Cloud-based distributed batch of signal processing infrastructure such as: Hadoop allows scaling the data analysis for jobs up or down very easily which makes analysis flexible. With flexibility in data analysis jobs, the frequency of analysis jobs can be varied [2].

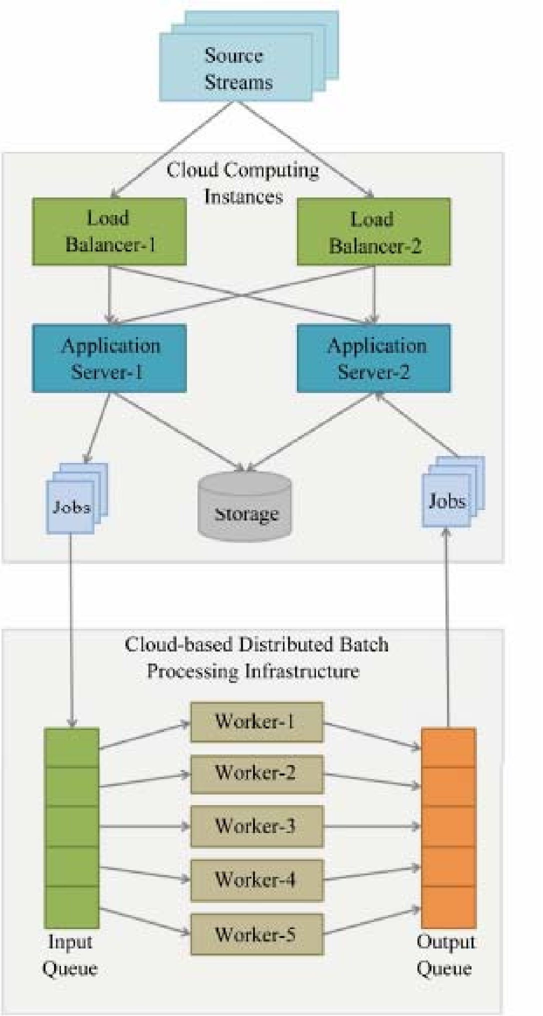

Fig. 4 Cloud-based architecture used by our proposed framework for data driven ITS that leverages a distributed batch processing infra-structure [2].

6. REAL TIME TRAFFIC CONTROL USING WAVELET NEUNAL NETWORKS SIGNAL

A Wavelet transform is a “small wave”, which grows and decays within a limited time period. A Wavelet is in clearly contrary to “big wave”,[3] which swing up and down for a very long, even infinite time period, for instance, the sine wave is a typical “big wave”

$$(\sin(u)\ .\ \text{where } u \in (-\infty,+\infty))$$

By defining a real value function $\psi(\mu)$, over a real axis $(-\infty,+\infty)$, and the quantifying notion of a wavelet signal can be expressed as follows [3]:

$$\int_{-\infty}^{+\infty} \psi(\mu)du = 0 \tag{1}$$

and

$$\int_{-\infty}^{+\infty} \psi^2(\mu)du = 1 \tag{2}$$

Therefore, in a given interval $[-T,+T]$, for $0 < \in < 1$, there must be

$$\int_{-T}^{+T} \psi^2(\mu)du > 1 - \in \tag{3}$$

From Eq. (2) describes a real function $\psi(\mu)$ having a movement away from zero, while Eq. (1), by describes that movements above zero must be canceled out by movements below zero. Since the interval $[-T,+T]$ is utmost small compared to the infinite long real time axis $(-\infty,+\infty)$, the non-zero movement of $\psi(\mu)$ therefore can be regard as limited to a small time interval. For in order to utilize wavelets transform signal, the following:

$$C_\psi = \int_0^\infty \frac{[\psi(f)]^2}{f} df\ , \quad \text{where } 0 < C_\psi < \infty \tag{4}$$

Under this condition, a wavelet transform $\psi(\mu)$ is admissible, thus allowing reconstruction of a function from its wavelet transform signal [3].

Using wavelets analysis allows isolating and processing specific types of patterns concealed in the masses of data. Wavelet transform of time-frequency localization for the signal then process these components with WNN. The Morlet wavelet function $\psi(\mu)$ is often referred to as the mother wavelet as from Eq. (5)

$$\psi_{\mu,s}(t) = \left(\frac{1}{\sqrt{s}}\right)\psi\left(\frac{(t-\mu)}{s}\right) \tag{5}$$

where s > 0, $\mu \in$ real value number, s is the scaling parameter , μ is the translation parameter, t is the time, and $\psi_{\mu,s}(t)$ is the basis function of the wavelet.

The Morlet wavelets are used for wavelet transform and selected as the hidden layer nodes in the future neural network construction. For in each element of the wavelet transform set is a scaled (dilated or compressed) and translated, that can be formulated as follows [3]:

$$\psi(t) = \cos(1.75t)\exp\left(-\frac{t^2}{2}\right) \tag{6}$$

The continuous wavelet transformation is designed to deal with the time series defined over a continuous real:

$$W(\lambda,t) = \int_{-\infty}^{+\infty} x(\mu)\psi_{\lambda,t}(\mu)d\mu, \quad \text{where } \psi_{\lambda,t}(\mu) = \frac{1}{\sqrt{\lambda}}\psi\left(\frac{\mu-\tau}{\lambda}\right) \tag{7}$$

where $\lambda > 0$ and $-\infty < t < +\infty$, $x(\mu)$ is the function or signal. Wavelet transformation can be localized in both time and frequency domains The idea behind of the continuous wavelet transform (CWT) is to calculate the amplitude coefficient thus making $\psi_{\lambda,t}$ best fit the signal $x(\mu)$, given λ dilation and τ translation factor.

The discrete wavelet transformation (DWT) are main classes for different wavelet function, the wavelet can be reconstructed following inverse transformation

$$x(t) = \frac{1}{C_\psi}\int_{0}^{\infty}\left[\int_{-\infty}^{+\infty}(x,\psi_{\lambda,t})\psi_{\lambda,t}(t)d\mu\right]\frac{d\lambda}{\lambda^2} \qquad (8)$$

where C_ψ is defined in Eq. (4).

A critical sampling of CWT defines the resolution of DWT from both the time and frequency perspective [3]. The wavelet coefficients can be found by wavelets that follow the values given by:

$$f(t) = \sum_{t=1}^{k}\varphi\left(2^{j-1}t\right)+\psi\left(2^{j-1}t\right) \qquad (9)$$

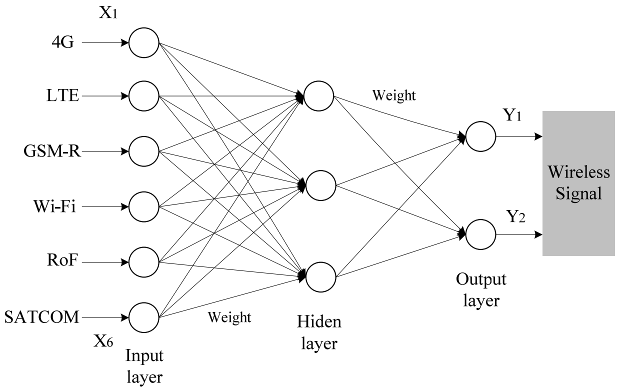

Fig. 5 Wavelet Neural Networks transform (WNN) of signal processing for wireless communication

An example of a 3-layer feed forward artificial neural network with n inputs, n hidden nodes, and n outputs is illustrated as shown in Fig. 5. The weights of the WNN signal are obtained through training. Training is the algorithmic procedure. The weights of the WNN such a network are estimated. The neural network is trained by learning rules then determines suitable weights by itself. Generally, there are two types of learning, supervised and unsupervised learning.

7. BROADBAND INTERNET ACCESS ON HSR TO WIRELESS COMMUNICATIONS

7.1 Wi-Fi

Rewiring may also be needed every time the train is reconfigured. In addition, which it is generally accepted that replication concept of Wi-Fi access points within the train is not only the best technical solution to create "connected trains", but also the ideal client interface [1]. Thus Wi-Fi is a well-known technology with unlicensed bands, easy to roll out and cost effective.

Fig. 6 Intelligent transportation systems of high speed railways performance at Bangkok, in Thailand

The different standards of Wi-Fi IEEE 802.11 are reminded**,** which it improves the previous standards: IEEE 802.11a on the 5GHz band, and IEEE 802.11b on the 2.4GHz band by the following enhancements:

1) The standard relies on the Multiple Input Multiple Output (MIMO) technology

2) The aggregation of channels allows increasing the bandwidth to 40 MHz.

From two different topologies are studied in order to construct the networks on board railway using Wi-Fi technology.

7.2 GSM-R

GSM-R for railways was created as an extension of GSM, with a focus on rail operations and to provide a standardized digital communications protocol that will be interoperable and cost efficient. The aim was to replace analog systems traditionally used in the railroad environment with modern wireless all digital systems. But the network had to follow some basic requirements for train to wireless communications, such as controller driven communications, automatic train control [1].

7.3 4G network & LTE

From described of GSM-R/2G is transitioning to 4G network deployments. WIMAX, and now WIMAX-2, have been an integral of the transition to 4G networks. The release of WIMAX-2 elevated WIMAX into the group of 4G technologies. Another 4G technology is 3GPP's Long Term Evolution, and LTE can work as a backbone network any communication technology.

7.4 Radio over Fiber (RoF)

RoF is a recent advance in high capacity broadband access for railways. The aggregate capacity can reach up to 1 Gbps using RoF. The "Pico cells" introduced in

RoF signal can be enhance bandwidth utilization for the large number of users as with statistical multiplexing, which can be operates over on 60 GHz frequency and relies on millimeter-wave technology [2].

8. RESULTS OF TRAFFIC CONTROL TO CONNECT THE TRAIN TO INTERNET

The results of the train traffic control system testing uses advanced information communication technologies (ICT) by applying WNN transform signal processing for wireless communication technologies to of future high speed railways performance in Thailand, which can be used to link the train to the Internet backbone. There are several technological solutions of control system that can be used to provide a broadband Internet access on board trains. Services to passengers are very demanding in terms of throughputs, as presented above, using other applications requiring broadband with Internet access on HSR to wireless communications, to implement various monitoring and traffic control, such as train timetable management and changes, operational control of trains on tracks, and automatic route control based on the train timetable. In case of delay, it also has an automatic train operation recovery function.

Broadband for wireless communications technologies to needs for railway applications are quite growing since several years. The results in Fig. 7 shows for illustrates an overall HSR performance comparison of mentioned wireless technologies against high speed of the survey analyze them further, and in Fig. 8 shows the results of achievable throughput for future HSR performance of wireless technologies by show the detail as in Table 1.

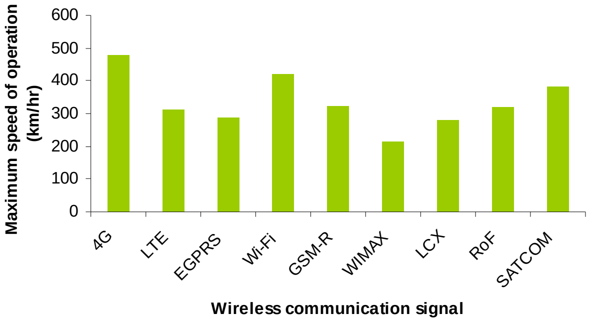

Fig. 7 Results of maximum speed for future railways performance of wireless technologies

Table 1 Results of real-time traffic control& supported throughput of HSR by WNN signal for wireless

Signal	Real-time traffic signal control		Max. supported throughput
	*t*max	*t*min	
4G	90 sec	45 sec	29.9 Mbps
LTE	20 sec	8.6 sec	>300 Mbps
GSM-R	42 sec	20 sec	7 kbps
Wi-Fi	60 sec	39 sec	>125 Mbps
RoF	36 sec	25 sec	>1.6 Gbps
LCX	32 sec	18 sec	>58 Mbps
SATCOM	46 sec	27 sec	>1.2 Gbps

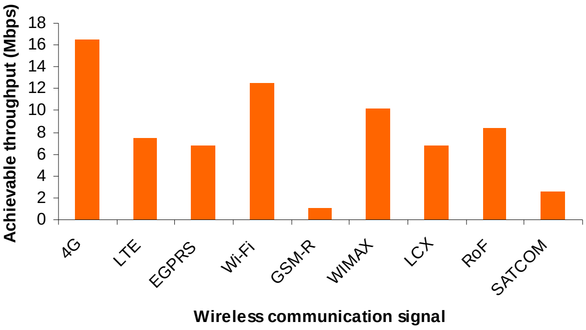

Fig. 8 Results of achievable throughput for future HSR performance of wireless technologies

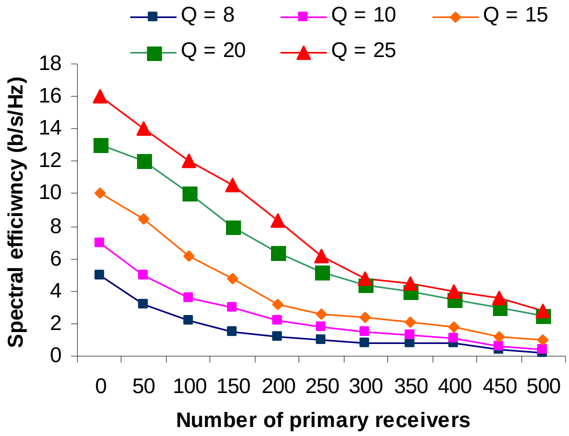

Fig. 9 Results of spectral efficiency by WNN transform signal for wireless communications in Q value:dB

9. CONCLUSION

High speed railway management by applying WNN signal for wireless communication systems can be used to enhance the railway signaling and a real time traffic control systems in order to increase the railway safety, efficiency, comfort and security for passenger with intelligent transportation in traveling. Several railway management and wireless communication systems have been defined. The survey could find that 4G networks with LTE-R increasingly maintain train operations and user plane broadband access. The results of spectral efficiency of HSR using WNN transform signal for wireless communications as shown in Fig. 9.

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