

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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HUAWEI TECHNOLOGIES CO. LTD,  
Petitioner,

v.

NOKIA SOLUTIONS AND NETWORKS OY,  
Patent Owner.

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Case IPR2017-01540  
Patent 9,185,688

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**DECLARATION OF DR. PAUL S. MIN  
IN SUPPORT OF PATENT OWNER PRELIMINARY RESPONSE**

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## **I. INTRODUCTION**

1. My name is Paul S. Min. I have been retained by Patent Owner Nokia Solutions and Networks Oy (“Patent Owner”) to provide expert opinions in connection with this *inter partes* review.

2. I am being compensated for my work in this matter at my standard consulting rate of \$450 per hour. I am also being reimbursed for all incurred expenses. My compensation is not contingent upon the outcome of this action. I have no other interests in this action or with any of the parties.

3. My opinions are also based upon my education, training, research, knowledge, and personal and professional experience.

## **II. QUALIFICATIONS**

4. I am currently a Senior Professor in the Department of Electrical and Systems Engineering at Washington University in St. Louis. A complete list of my publications, professional activities, and honors that I have received is fully set forth in my *curriculum vitae* (see NSN-2006). A representative list of cases in which I have previously given testimony is also included in NSN-2006.

5. I received a B.S. degree in Electrical Engineering in 1982, an M.S. degree in Electrical Engineering in 1984, and a Ph.D. degree in Electrical Engineering in 1987 from the University of Michigan in Ann Arbor. I received several academic honors, including my B.S. degree with honors, a best graduate

student award and a best teaching assistant award during my M.S. study, and a best paper award from a major international conference for reporting results from my Ph.D. thesis. Since 2015, I have been a Senior Professor in the Department of Electrical Systems Engineering at Washington University in St. Louis. Prior to being named a Senior Professor, I was an Associate Professor in the Department of Electrical and Systems Engineering from 1996 to 2014. Additionally, from 2011 to 2014, I served as the Chair of the Undergraduate Curriculum, and from 2000 to 2002, I served as the Chair of the Graduate Curriculum. From 1990, until being granted tenure in 1996, I was an Assistant Professor in the Department of Electrical Engineering.

6. After receiving my Ph.D., I worked at Bellcore in New Jersey from August 1987 until August 1990. At Bellcore, I was responsible for evolving the public switched telephone network (POTS) into a multi-services voice and data network that incorporated packet switches, optical technologies, and wireless technologies.

7. In September 1990, I joined the faculty at Washington University in St. Louis.

8. At Washington University, I have conducted research in communication, computing, and related electronic hardware and software. My research group has pioneered a new paradigm for designing electronic circuits that

can alleviate the speed and performance mismatch against optical technology. I have received several grants from U.S. federal agencies, including the National Science Foundation and the Defense Advanced Research Project Agency, and numerous contracts from companies and organizations around the world.

Specifically related to the technology matters in this litigation, I have researched a variety of wireless communication technologies, including LTE, LTE-A, CDMA, WCDMA, OFDM, FDD, SC-FDMA, and TDD. I have an extensive background and experience in each of these technologies.

9. As a faculty member at Washington University, I have taught a number of courses in electronics, communication, and computing at both the undergraduate and graduate levels. For example, I have taught communication theory (Washington University ESE 471), transmission and multiplexing (Washington University ESE 571), and signaling and control of communication networks (Washington University ESE 572).

10. I have supervised more than 50 students, 12 of whom received a doctoral degree under my guidance. A number of doctoral theses that I have supervised relate specifically to wireless cellular technology. In particular, my students and I have published a number of peer-reviewed articles on resource allocation, scheduling, modulation, mobility management, and multiplexing. Several of these articles received accolades in the field. For example, in 2011, we

received a best paper award in 3G WCDMA-related mobility and resource management at the prestigious Mobility 2011 international conference.

11. In addition to my responsibilities as a university faculty member, I have founded two companies. In May 1997, I founded MinMax Technologies, Inc., a fabless semiconductor company that developed switch fabric integrated circuit chips for the Internet. In March 1999, I founded Erlang Technology, Inc., a fabless semiconductor company that focused on the design and development of integrated circuit chips and software for the Internet. One of Erlang's products received a best product of the year award in 2004 from a major trade journal for the electronics industry.

12. While at Erlang and MinMax, I prototyped several different versions of Radio Network Controller (RNC), Serving GPRS Support Node (SGSN), and Gateway GPRS Support Node (GGSN). As these devices are highly specialized routers and/or switches, I have incorporated in the prototypes various components I have designed (e.g., switch fabrics, network processors, and packet classifiers) as well as the customized protocol stacks required to perform functions required to these devices.

13. Outside my own start-up companies, I have also served in various technology and business advisor roles for other companies and organizations around the world. I was the main technical author for one of two winning proposals

to the Korean government for CDMA wireless service licenses (1996). I was responsible for designing a commercial scale IS-95 CDMA cellular network, which I understand to be one of the earliest such networks deployed in the world. I worked with numerous engineers and scientists around the world to implement this commercial-scale cellular network before IS-95 CDMA was widely accepted. I have also been involved in a semiconductor company that specializes in semiconductor memories such as flash EEPROMs as a board member and as a technical advisor (2007-2011).

14. In addition, I have extensive experience with processing of CDRs (Charging Data Records or Call Detail Records). In the mid to late 1990s, I consulted with several telecommunications companies, including Brooks Fiber and Access America, to design their billing software, which processed large volumes of CDRs to produce the customer bills.

15. I am a member of and have been actively involved in a number of professional organizations. For example, I have served as the Chair of the Saint Louis Section of the IEEE with more than 3,000 members (2014), and a member of the Eta Kappa Nu Honor Society for electrical engineers. I have also been an Ambassador of the McDonnell International Scholars Academy (2007-2013).

16. In my more than 30 years of experience with telecommunications technology, I have acquired significant knowledge about telecommunications

systems industry standards, standard setting organizations such as 3GPP, and the rules and document policies that those organizations have in place to develop industry standards.

17. I am a named inventor on nine U.S. patents, and I have extensively published technical papers in international conferences and journals, technical memoranda and reports, and given a number of seminars and invited talks. Many of these papers are specifically within the context of the 3GPP standard. I have also organized several international conferences and served as an international journal editor.

### **III. COHERENT DETECTION**

18. I have been asked to provide an explanation of what a person of ordinary skill in the art would understand the term “coherent detection” to mean in the 2007-08 timeframe as it relates to cellular communications. I have also been asked to explain what a reference signal is and how it is used.

19. To understand coherent detection, a basic understanding of one of the fundamental problems in wireless communications is necessary. Specifically, wireless communications are transmitted over the air. When information is transmitted on a wireless channel over the air, the transmission is subject to interference by other unwanted wireless transmissions or buildings or other physical structures.

20. A UE and/or base station or eNodeB must account for interference when decoding a received signal. Coherent and non-coherent detection are two mechanisms for handling noise introduced to a signal due to interference.

21. For coherent detection, the system uses a known signal as a reference point for understanding what types of interference are currently present in a communication channel. The known signal is referred to as a reference signal or pilot signal.

22. When coherent detection is used, the reference signal and desired signal are typically transmitted through the same channel or resource. Once the receiver receives the reference signal, it will compare the received reference signal to the known reference signal to determine the characteristics of the channel through which the signals have traveled. This process is referred to as channel estimation, and the information obtained using channel estimation can be used by the receiver to properly detect the desired signal.

23. The reference signal used in this process must be known to the transmitter and receiver. Reference signals have been used in cellular systems prior to 2008. Some of the reference signals have been modulated prior to transmission and other reference signals are unmodulated. Modulated and unmodulated signals can be used for coherent detection as long as the modulation

technique and underlying signal are both known (as they would be for a reference signal).

24. I have been asked to provide specific examples of modulated references signals that were used for coherent detection prior to October, 2008. There are many examples, but I will describe two examples from the LTE technical specifications published in March of 2008.

25. *First*, in LTE, a demodulated reference signal (“DM-RS”) is used for coherent detection of a Physical Uplink Control Channel (“PUCCH”). A PUCCH can have different formats, and the DM-RS signal that is sent is different for certain formats.

26. For example, the LTE Technical specifications describe the following sequence for the DM-RS:

#### 5.5.2.2.1 Reference signal sequence

The demodulation reference signal sequence  $r^{\text{PUCCH}}(\cdot)$  for PUCCH is defined by

$$r^{\text{PUCCH}}(m' N_{\text{RS}}^{\text{PUCCH}} M_{\text{sc}}^{\text{RS}} + m M_{\text{sc}}^{\text{RS}} + n) = \bar{w}(m) z(m) r_{\text{u,v}}^{(\alpha)}(n)$$

where

$$\begin{aligned} m &= 0, \dots, N_{\text{RS}}^{\text{PUCCH}} - 1 \\ n &= 0, \dots, M_{\text{sc}}^{\text{RS}} - 1 \\ m' &= 0, 1 \end{aligned}$$

For PUCCH format 2a and 2b,  $z(m)$  equals  $d(10)$  for  $m = 1$ , where  $d(10)$  is defined in Section 5.4.2. For all other cases,  $z(m) = 1$ .

(NSN-2001, §§ 5.5.2.2.1)

27. The DM-RS is generated using  $z(m)$ .  $z(m)$  is set to 1 for all PUCCH formats other than format 2a and 2b. For formats 2a and 2b, it is set to  $d(10)$ , which is defined in section 5.4.2.

28. Section 5.4.2 describes that  $d(10)$  is a modulation symbol. For example, Table 5.4.2.-1 lists the modulation symbol for PUCCH formats 2a and 2b depending on the value of the bits to be transmitted:

**Table 5.4.2-1: Modulation symbol  $d(10)$  for PUCCH formats 2a and 2b.**

PUCCH format	$b(20), \dots, b(M_{\text{bit}} - 1)$	$d(10)$
2a	0	-1
	1	1
2b	00	-1
	01	$j$
	10	$-j$
	11	1

(*Id.* at § 5.4.2).

29. This same modulation is used for the information bits that are transmitted on the PUCCH (*id.*).

30. *Second*, in LTE, a UE-specific reference signal is transmitted in the downlink for coherent detection of the Physical Downlink Shared Channel (“PDSCH”) (*id.* at §§ 6.10.3, 6.10.3.1).

31. The LTE technical specifications describe that UE-specific reference signal ( $r(m)$ ) is generated and then mapped to “complex-valued modulation

symbols.” (*id.* at § 6.10.3.2). This process results in the modulation of the UE-specific reference signal.

32. From these examples, it is clear that, at least by the 2007-08 timeframe, it was known that a reference signal used for coherent detection could be modulated or unmodulated.

#### **IV. CONCLUSION**

33. In signing this declaration, I recognize that this declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed this 18th day of October, 2017.

Respectfully submitted,



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Dr. Paul S. Min