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Dear Sir/Madam:

I am pleased to write in support of Dr. Noah Jacobsen application for the Research Scientist position in your department.

Let me provide a few details about myself. I am a distinguished member of technical staff of Communications and Statistical Sciences Research Department of Bell Laboratories, Nokia. I am an IEEE Fellow. My research interests are focused on Information Theory, Communication Theory, Classical and Quantum Error Correcting Codes, and massive MIMO systems. I have authored over 90 publications in my field, including over 55 articles in international journals and collected volumes. I will gladly provide more information about myself upon request.

Dr. Jacobsen has an excellent record of industrial and academic research achievements. Below I briefly describe some of them.

I first met Noah at Bell Labs in 2006 when our groups were involved in a collaboration on multi-antenna technology for cellular systems and since then we have worked together on a number of research projects. We had numerous discussions on error correcting codes and information theory, and I attended several his presentations at the Bell Labs research seminars. I was always impressed by the presented results and by the clearness of his talks.

During his work at Bell Labs Dr. Jacobsen has performed basic research in the field of error correcting codes. He proposed a new construction of a rate-compatible Low Density Parity Check (LDPC) code for cellular systems with Hybrid Automatic Repeat Request (H-ARQ) protocol. Instead of puncturing bits from a low-rate "mother" code, Dr. Jacobsen proposed a way for extension of a high-rate "daughter" code to codes for obtaining LDPC codes of successively lower rates. The parity-matrix extension technique he developed yields rate compatible LDPC codes that approach capacity at each given code rate. I found his code design to be effective and very useful for practical applications. This construction made a contribution to UMB (3GPP2) standard. In addition, the results on this topic were published in the Proceedings of *IEEE Vehicular Technology Conference* Baltimore, 2007. His work on rate-compatible LDPC codes was awarded a patent.

Dr. Jacobsen's research at Bell Labs also includes contributions on the topic of cooperative communications. He established a new lower bound on the capacity of the cooperative relay channel. His results show that the cut-set upper bound on the capacity of the half-duplex relay channel can be approached using a simplified code in which the source does not simultaneously transmit with the relay. This result was complemented by the demonstration of an LDPC code that approaches the upper bound on capacity of a half-duplex relay channel. Dr. Jacobsen's work on relay codes motivated the inclusion of cooperative relays in the LTE-A standard. His results on cooperative relays appear in the proceedings of the 2009 *Conference on Information Science and Systems*.

Dr. Jacobsen obtained his first research results in 2003 when he was granted a National Science Foundation fellowship for work at Yokohama National University, Japan. At YNU, he worked

with Dr. Ryuji Kohno on channel coding for an ultra-wideband communication channel. An ultra-wideband channel is typically characterized by a large inter-symbol interference. Dr. Jacobsen showed that a code optimized for an AWGN channel, in combination with an iterative interference canceling receiver, has the performance approaching the performance of a code that is directly optimized for the inter-symbol interference channel. This result appears in an *NSF technical report.*

In 2003–2006, Dr. Jacobsen was a graduate student and postdoc at the University of California, Santa Barbara. His doctoral work was focused on coding and modulation for noncoherent radio communication systems. In particular, he showed that conventional digital modulation constellations used in coherent systems, in which channel state information is obtained via downlink pilots, are inferior to constellations specifically designed for non-coherent communication systems, that do not use any pilots. Furthermore, by suitable choice of channel code for iterative demodulation and decoding, the noncoherent system can achieve higher communication rates than a coherent system when the fading rate in time and frequency is fast due to mobility and/or large delay spreads. This his work was published in *IEEE Transactions on Communications,* in Dec. 2008.

His other work, conducted at Univ. of California, showed that multi-antenna processing gains can be efficiently obtained in a noncoherent radio system. Most MIMO systems assume the channel matrix between sender and receiver being known. Thus, the demonstration of a practical noncoherent system that achieves gains from the use of multiple antennas without explicitly estimating the channel matrix is an interesting result. This work was extended to the case of an interference channel in which the interferer is assumed to be separated from the user by a given angle. In this case it is shown that a multi-antenna receiver is able to resolve the source from interference using a low rate pilot signal and that the pilot energy needed for this purpose is much less than the energy that would be needed for explicit channel estimation. This work was published in *IEEE Trans. Communications,* in June 2008.

From the above results one can see how broad and deep research interests of Dr. Jacobsen are. Dr. Jacobsen published and presented his results in the foremost research journals and conferences in his field. I have found his papers of being very diligent and of the highest quality with no corners cut. His contributions have made a profound impact. I strongly recommend appointing him to the Research Scientist position within your department.

Should you need any clarification or more information from me, I will be happy to provide it.

Yours Sincerely,

Alexei Ashikhmin