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TAPR Looks to Advance the Work of John Stephenson, KD6OZH

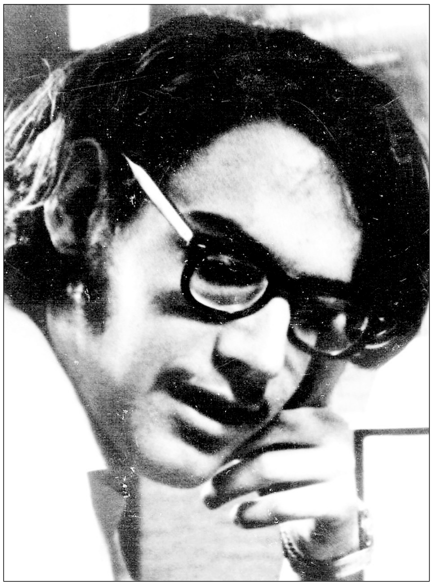
The Amateur Radio community lost a valuable contributor on July 27, 2014 with the passing of John Stephensen, KD6OZH. John was born and raised in Fresno, California, and graduated from McLane High School in 1970. He studied electrical engineering at the University of California, Santa Barbara.

John developed his interest in Amateur Radio and electrical engineering at an early age, after discovering his father's shortwave radio. John pursued these interests as a hobby and a profession throughout his life.

He was a gifted engineer and independently designed an early desktop computer in 1972, while working as an electrical technician at MiniCar Corporation in Goleta, California. He then started one of the first personal computer companies, PolyMorphic Systems, with two partners, Brian Wilcox and Richard Petersen. John was the principal product designer. John later worked as an engineer at CompuCorp in Santa Monica, where he was Director of Systems Engineering. In 1985 he co-founded the ISO-based network communications company Retix in Santa Monica, where he was Vice President of Technology Development. In 1993 John joined another Santa Monica-based computer company, ISOCOR, where he became Vice President for Technology.

John returned to Fresno in 2007, and started Millenium Radio to develop technology for software defined radio applications for use on wireless networks. He was working on the technology when he died.

John was the author of many technical publications concerning computer, digital radio and related technologies. He was a participant in the development of standards for computer network and internet communication protocols, working with industry groups and the US National Institute of Standards and Technology (NIST).



John Stephenson, KD6OZH

John was a member of the ARRL High-Speed Multimedia (HSMM) Working Group, and volunteered to develop an RF modem to augment IEEE 802.11 (WiFi) equipment to provide longer-distance communications links. He developed numerous prototypes of both direct conversion and quadrature sampled Software Defined Radios. The prototypes were designed in CadSoft *Eagle*, and manufactured at his home RF lab in Fresno, California.[1] He stated in an e-mail that they "have been tested over distances of up to 8 miles on 70 cm in a 1 MHz channel with 50 W PEP, using one mobile antenna at 10 feet and one base antenna at 25 feet."

An orthogonal frequency division multiplexing (OFDM) modem was the core of John's work, and his goal was high: to cover the San Joaquin Valley and surrounding mountains with a high-speed mesh network. John used two layers of error-correcting codes (dual-ECC) in his modem to ensure the reliable transfer of data. The inner code minimizes the SNR required by the data link and the outer code compensates for fading. The radio functions as a multi-hop bridge, similar to 802.11s, but uses multiple channels to allow multiple simultaneous data transfers, minimizing contention in ad-hoc and mesh networks. One channel is the control channel and multiple data channels may be used.

John wanted to support point-to-point packet communications, as well as broadcast voice chats with the new modem. He noted that the dual-ECC is especially important for broadcast and multicast data, where it would be very inefficient for all of the recipients to transmit acknowledgements. Source multi-point relays (S-MPR) are employed to select a minimal set of relay stations that still ensure complete coverage of all stations in the network. He dubbed the protocol the Advanced Wireless Mesh Protocol (AWMP) and optimized it for broadcast, multicast, and unicast routing.[2]

The modem is built on top of a custom designed processor named the CPU16F. It's a 16-bit Reduced Instruction Set Computing (RISC) machine implemented as a soft core in a Xilinx Field Programmable Gate Array (FPGA). The processor is described in his 2010 Digital Communications Conference paper titled "An FPGA-Based Transceiver Module."[3] John coded a custom assembler in *Delphi*, and all of the radio's software was written in this format.

The CPU16F processor itself was

[1]Notes appear on page 24.

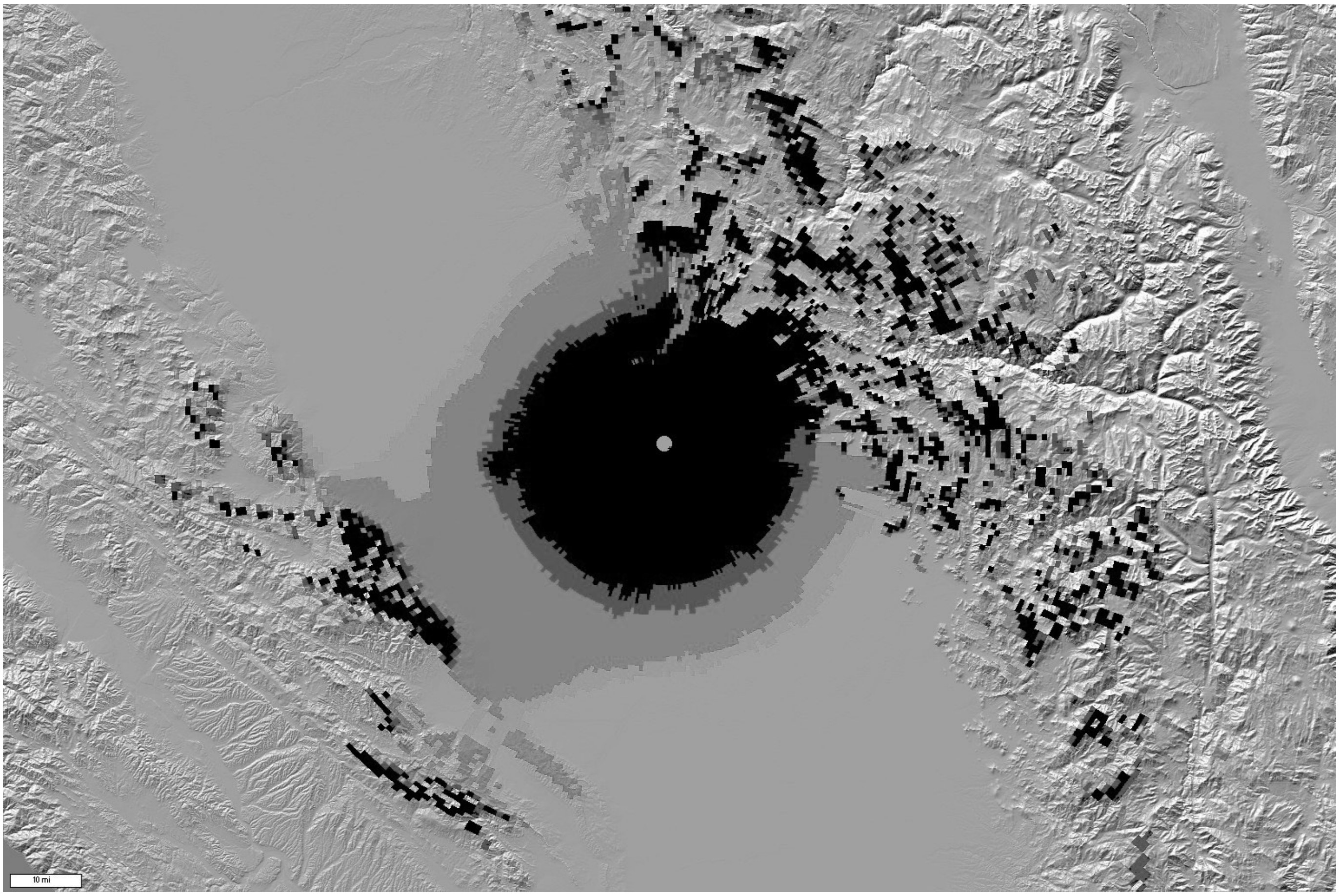


Figure 1 — This map, centered on Fresno, California, shows the 70 cm coverage of John Stephensen's orthogonal frequency division multiplexing (OFDM) modem. The map shows an analysis using the Radio Mobile software package for a 12 dBi antenna at 90 feet, and transmitter powers of 5 W, 10 W, 100 W, and 200 W.

designed and written in *Verilog*, as were the many coprocessors necessary to support the wideband OFDM modes. For example, trellis-coded differential 8-PSK modulation with a rate-2/3 inner error correcting code (ECC) is implemented within the FPGA fabric and accessed from the soft core processor via I/O instructions.

The prototypes were manufactured by hand at his home. The setup consisted of quality rework equipment, including a hot air bath and solder paste dispenser. A home-brewed vacuum placement tool allowed him to work with small surface-mount packages including leadless integrated circuits (ICs) right at his desk.

Towards the end of his life, John was working on an OFDM modem for 1.8 Mbps links. He assessed setting up networks with different power levels (from 1 to 100 W) and antenna heights (45 and 90 foot towers) on the 70 cm and 23 cm Amateur Radio bands. See Figure 1. The work was analyzed using the *Radio Mobile* software package.[4]

John donated his fully operational desk to TAPR. His *Windows XP* computer was set up with two DCP-6 prototypes connected via an RF combiner, demonstrating the OFDM modem. The last written notes we have describe how to turn on and load the prototype demonstration. It has been carefully wrapped up and photographed for further analysis. John donated a cash sum plus all of his research documentation and hardware to TAPR so that interested parties may build upon his work.

John's legacy includes many well-documented DSP functions written in *Verilog*. While this code can be used as part of John's SDR, it also forms a basis for building new DSP functions in *Verilog* without starting from scratch. Well-written, documented, reusable DSP modules are also an excellent learning tool, both for DSP and *Verilog*. TAPR intends to make all of John's code available on its servers for interested developers to use as they see fit. While TAPR is still working to determine the best way to achieve the maximum benefit to the community from John's work and generosity, we welcome proposals from interested parties interested in building upon John's research. Did you know John? Did you work with him? TAPR would like to hear from you! John left us way too soon and way too abruptly. John, we will miss you!

You can contact TAPR via e-mail at: **taproffice@tapr.org**, call the office at 972-671-8277 or write to: TAPR, PO Box 852754, Richardson, TX 75085-2754.

Notes

[1]CadSoft *Eagle* is available from **cadsoftusa.com**.

[2]John B Stephensen, KD6OZH, "A Software Defined Radio for Mesh Networks," 2013 ARRL/TAPR Digital Communications Conference. This paper is available for download from: **www.tapr.org/pdf/DCC2013-SDR-Mesh-KD6OZH.pdf**.

[3]John B. Stephensen, "An FPGA-Based Transceiver Module," 2010 ARRL/TAPR Digital Communications Conference. This paper is available for download from: **www.tapr.org/pdf/DCC2010-FPGA-BasedTransceiver-KD6OZH.pdf**.

[4]The *Radio Mobile* software package is available from: **www.cplus.org/rmw/english1.html**.

[5]The colorized version of Figure 1 is available for download from The ARRL *QEX* files website. Go to **www.arrl.org/qexfiles** and look for the file **5x15 Stephensen-Fig-1.zip.**