1 DR. BRIAN KELLEY, PI: WIRELESS NETWORK CLOUD: THEORY AND SMART GRID APPLICATION

PI Vision Statement: We envision a future where immense data center computing resources are communicated through ultra-high capacity wireless networks to remote mobile units in a metropolitan area. This is done in such a way that the mobile unit of the future will increasingly be optimized around access, store, forward, and interface emulation protocols. Such services will be communicated to mobiles from data centers. Thus the physical processing for the mobile of the future will physically be performed on the data center, but will virtually appear as a local service task. Furthermore, the wireless services of the future (e.g. Network, Medium Access Control (MAC), radio link services, and RF waveform processing), rather than being relegated to cellular Radio Access Network (RAN) islands, will themselves reside on the cloud data centers. In essence, we envision the ultimate in computing convergence: the metropolitan area wireless network cloud (WNC) architecture. Three key attributes of a metropolitan area WNC are:

(1) The computation that would normally occur locally on mobile devices is physically displaced over speed of light wireless links and speed of light Radio over fiber links (RoF) to the cloud data center; a metropolitan area network involving this concept is shown in Figure 1. Note that the cloud data center antennas are on towers far away from the cloud. Instead, RoF links displaces the processing of the radio frequency (RF) signal from the cell tower to the cloud over the broadband RF fiber. The wireless band could be cognitive radio, cellular or unlicensed.

(2) We perform customer applications, wireless applications, and control applications on the cloud; this creates a convergence architecture that is ultra low cost and enable infinitely upgradeable devices and services; an architecture of the cloud data center and wireless tower is shown in Figure 2. A propose architecture of the wireless cloud is illustrated in Figure 3.

(3) The key pathway is mobile→RF uplink→cell tower antenna→RoF→cloud (WNC RF).

2 THIS RESEARCH WILL LEAD TO MAJOR ADVANCES IN THE FOLLOWING FIELDS

This research will lead to advances in areas related to the convergence of computing and advanced communications, and will be particularly beneficial to U.S competitiveness in:

- Spectrally efficient communications performed on data centers as evidenced by the trend of placing more communications in software defined radio technology. The latest (3GPP-LTE) 4G mobiles require 3 GOPs of processing (see [1],[2]). Cellular would migrate to a WNC.
- FCC cognitive radio on the WNC: secondary users dynamically self appropriate unused spectrum for wireless communication; the FCC is encouraging cognitive radio applications. The WNC will spur efficient utilizations of wireless spectrum on cognitive radio channels.
- The WNC architecture has been identified as an ideal system for the future Smart Grid (see our reference [3]). The PI leads UTSA’s $1.4 Million DOE smart grid efforts in this area (see Figure 4) and the PI is affiliated with CPS Energy. Many of the smart grid energy optimization methods of the future are based upon distributed renewable energy; future smart grids will, in an aggregated fashion across a metropolitan area, control car battery charging, place heating venting air conditioning (HVAC) closed loop demand response, or optimize distributed building energy. This requires several features ideal for integration with metropolitan area WNCs: the need to perform many varieties of protocols, the need for continual upgrade, aggregation of service access metropolitan areas, and low cost.
- Wireless relay computing architecture where mobile units are glorified relays and wireless network control: modern mobile smart phone are increasingly moving in this direction.
- Lower power clouds: this is already occurring and will continue to accelerate (see [1])

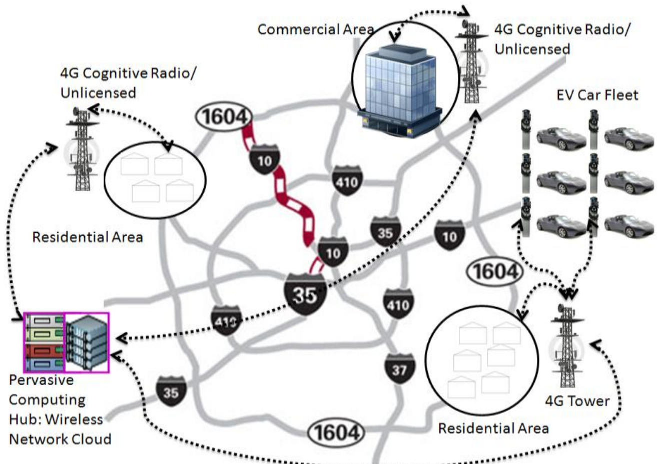

Figure 1: Metropolitan area pervasive computing grid

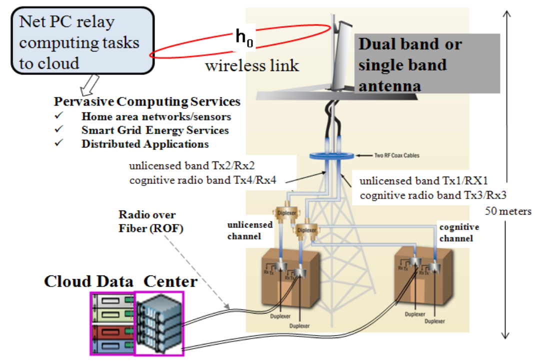

Figure 2: Ultra low cost pervasive computing Grid convergence architecture. The wireless computational processing, cell site processing, Net-PC processing, and remote application en services are all displaced via wireless and (radio) fiber optics from there local site to the cloud data center.

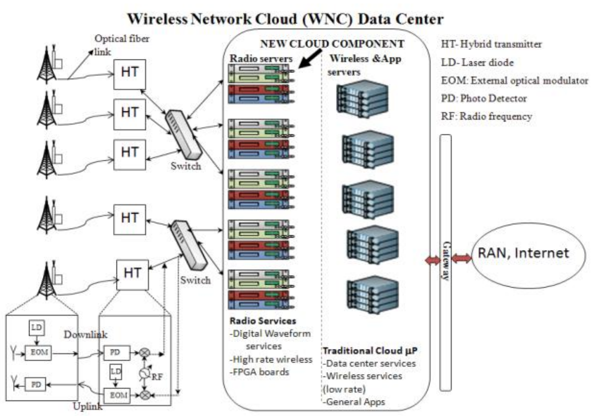

Figure 3: Mobile AMI Netbook Infrastructure Convergence Architecture. The smart meters can be fixed or mobile.

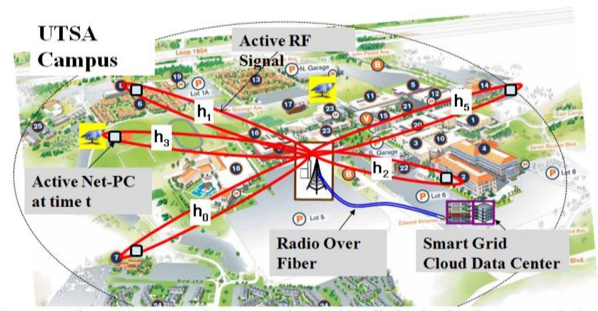

Figure 4: The UTSA pervasive computing grid cell site is ultra low cost wireless cloud based grid infrastructure. Latency is limited purely by the speed of light. Net PCs can wireless relay computing task on all UTSA buildings connect to the UTSA cell site antenna. This forms the wireless computing-grid network. The vast bulk of the computation physically occurs on a UTSA cloud data center connected to the cell antennas via Radio over fiber optic (ROF) cable. Net-PCs rapidly connect to wireless cloud to access services physically vi over-the-air software from cloud. Virtually, services appear to reside on the net-PC.

3 SELECTED WHITE PAPER REFERENCES

1. Kranthi Manoj, Brian Kelley, Jeff Prevost, Low Power Wireless Cloud Network Convergence Protocol for Next Generation Smart Micro-grids, *2010 WAC*.
2. Brian Kelley, "Software Defined Radio for Advance Gigabit Cellular Systems," DSP Handbook/Wireless, Networking, Radar, Sensor Array Processing, and Nonlinear Signal Processing, Chapter 22, 2009.
3. K Manoj, B. Kelley, etal., "Persistent Net-AMI for Microgrid Infrastructure Using Cognitive Radio on Cloud Data Centers," to appear in Special Issue of *IEEE System Journal*, 2011.

4 BACKGROUND AND EXPERIENCE OF BRIAN KELLEY, PH.D.:

Dr. Kelley received his BSEE from Cornell University, graduating Tau Beta Pi and Etta Kappa Nu. He received his MSEE and PhDEE from Georgia Tech's ECE Department where he was an ONR Fellow and a Georgia Tech Presidential Fellow. Dr. Kelley has 10 years of R&D efforts with Motorola and Freescale. Dr. Kelley joined the faculty of the UTSA as an Assistant ECE Professor in Communications in 2007. His interests include Software Define Radio, smart grid communications, computer engineering, 4G Cellular, Communications, and sensor networks. He is a Senior Member of the IEEE, Chair of the San Antonio IEEE Comm/DSP, and Associate Editor of Computers & Electrical Engineering, Elsevier, 2008, and a holder of 10 US patents.