Long Distance Wireless
(for Emerging Regions)

Sam Leffler
Errno Consulting
sam@errno.com

Background

- Deploying IT infrastructure too expensive many places
- Network connectivity can change people's lives
- Wireless technology advances have enabled new opportunities

TIER Project

- **Joint research project of:**
  - **UC Berkeley TIER group**
  - **Intel Research Lab, Berkeley**
- **Goal:** ***"address the challenges in bringing the Information Technology revolution to the masses of the developing regions of the world"***

http://tier.cs.berkeley.edu/

TIER WiLDNet Project

- **WiLDNet: WiFi-based Long Distance Networking**
- **Long Distance Wireless operation**
- **Commodity 802.11 parts**
- **Unlicensed spectrum**
- **Low cost**

What is “Long Distance”?

- 802.11 spec designed for indoor use
- Maximum station separation ~100’ (with standard parameters)

Long Distance is 30-100 Km…or more

Challenges of WiLDNet

- 802.11 MAC layer designed for short distance
- Can tweak link parameters for limited distance (e.g. ACK timeout)
- At some point hidden node problem dominates + b/w drops sharply
- External interference significant

Challenges of WiLDNet (cont)

- There are other problems too… (look closely for the monkey climbing the tower)

WiLDNet Protocol Design

- CSMA media access unsuitable
- TDMA instead
- Error recovery: Bulk ACK's
- Error correction: FEC

WiLDNet System Design

- High TX power radios good (but external PA's and high gain antenna work too)
- RX sensitivity important
- Signaling technique important:
  - OFDM weak at long distance
  - CCK effective but lower bandwidth

WiLDNet System Design (cont)

- 2.4GHz band crowded
- 900MHz band conflicts with GSM
- 4.9GHz good but lower power
- 5GHz good, especially upper-UNI
- Environmental factors affect band selection

LINK BUDGET CRITICAL...

Rural Connectivity Platform/RCP

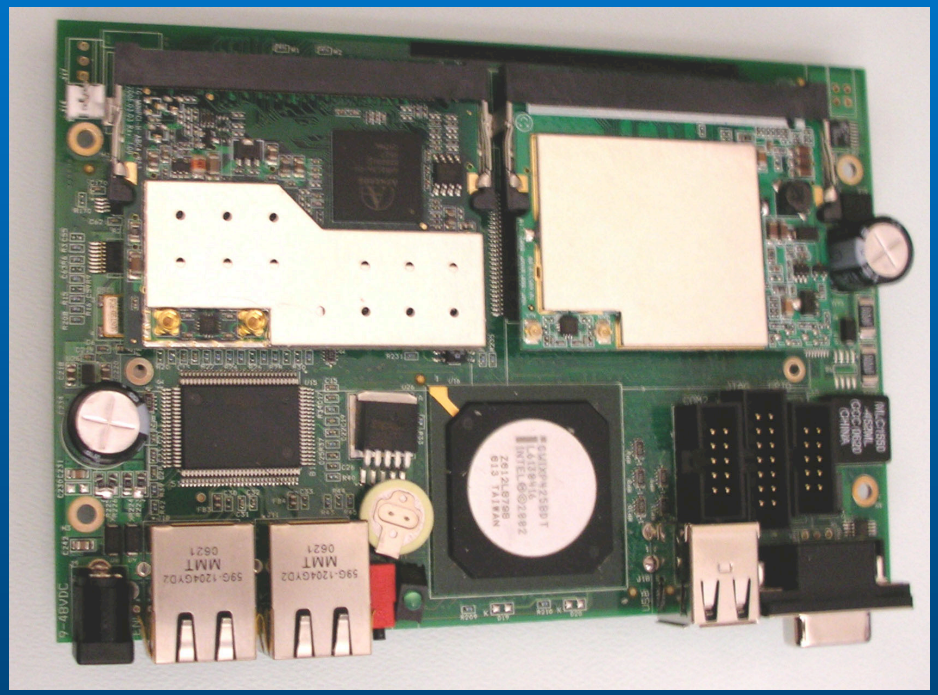
Offshoot of TIER WiLDNet work:

- **Production quality**
- **Easy to setup**
- **Flexible configuration**
- **Low maintenance**
- **(Low Power) ⇐ *didn't happen***

RCP Prototype System

Gateworks Avila 2348:

- **533MHz IXP425**
- **64-128M DRAM**
- **16M Flash Memory**
- **2x 10/100 Ethernet**
- **4x MiniPCI**
- **Compact Flash IDE**
- **POE (both ports)**
- **-40 to 85° C operation**



RCP Prototype System (cont)

Atheros cards:

- **Wistron DMCA-82**
- **Ubiquiti XR and SR**
- **Low power (AP)**

❤ **MMCX connector**

☠ **U.FI connector**

BE SKEPTICAL OF VENDOR CLAIMS...

RCP Prototype System (cont)

- **Software:**
  - **Custom Linux distro**
  - **Custom wireless support**
  - **Custom [auto-]configuration system**
  - **WEB-GUI (derived from TIER/m0n0wall)**
- **Field upgrade mechanism (download firmware, upgrade, rollback)**

RCP Network Design

- L2 bridged backbone
- Routed overlay
- Static IP assignment (hash of MAC)
- Dynamic IP allocation within CIDR
- DNS
- QoS for multimedia and VoIP
- Limited topology: not a mesh

Intranet traffic more important than Internet traffic...

RCP Wireless Design

- Fork of madwifi
- Uses public ath hal
- Support for high power wireless cards
- Support for 900MHz, etc. cards
- TDMA
- Multi-radio scanning
- Auto-configuration

RCP TDMA

- Different from TIER: no CLICK
- Use h/w for accurate slot scheduling (independent of distance)
- Affects only link layer
  - h/w QoS unaffected
  - transparent to upper layers
- High channel utilization

RCP TDMA (cont)

- Slot configuration dependent on h/w capabilities (e.g. timer accuracy)
  - typical config is 2x 10ms/slot
  - slots synchronized within ~2μs
- Self configuring
- Cannot overlap with standard 802.11

Test Deployments

- Venezuela: 279Km, point-to-point, 11b, 3-4Mb/s each direction, 6Mb/s combined
- Panama: short (<10Km), point-to-point, 11a
- South Africa: 3 stations (point-to-relay-to-point), 5.8GHz
- Ghana: >3 stations, variety of distances
- SF Bay Area: multiple links, distance varies but <30 Km

Future Work

- Steer-able antenna work (Alan Mainwaring of Intel Research)
- Better relay auto-configuration
- Look at TIER work: Bulk ACK's, multi-radio scheduling
- 802.11n parts: AMPDU Block ACK, higher resolution timers
- Antenna tuning/alignment tool
- Mesh integration (Merraki, OLPC)

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- Ubiquiti: Robert Pera

Availability

- Unknown: not a product
- TDMA implementation can be done with publicly available information and components