

A faded background image of a rural landscape. In the foreground, a wooden cart with large spoked wheels is parked on a dirt path. The background shows a green field, distant hills, and palm trees under a cloudy sky.

Rural Power

Issues and Solutions

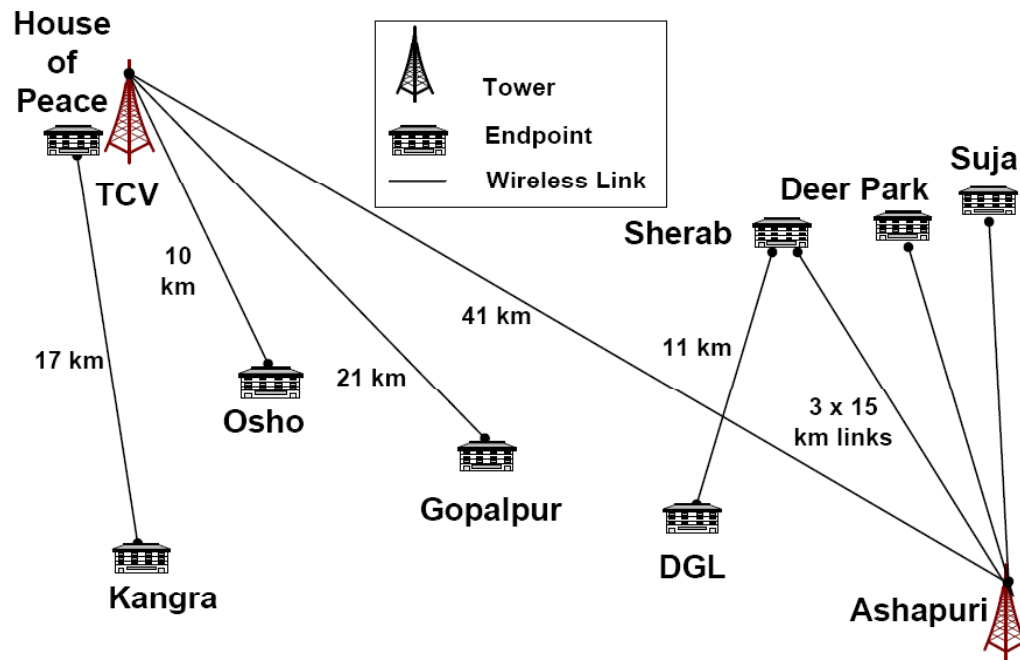
Sonesh Surana

Tier Workshop

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Joint work with Manuel Ramos, Yahel Ben-David, and Eric Brewer

AirJaldi Network



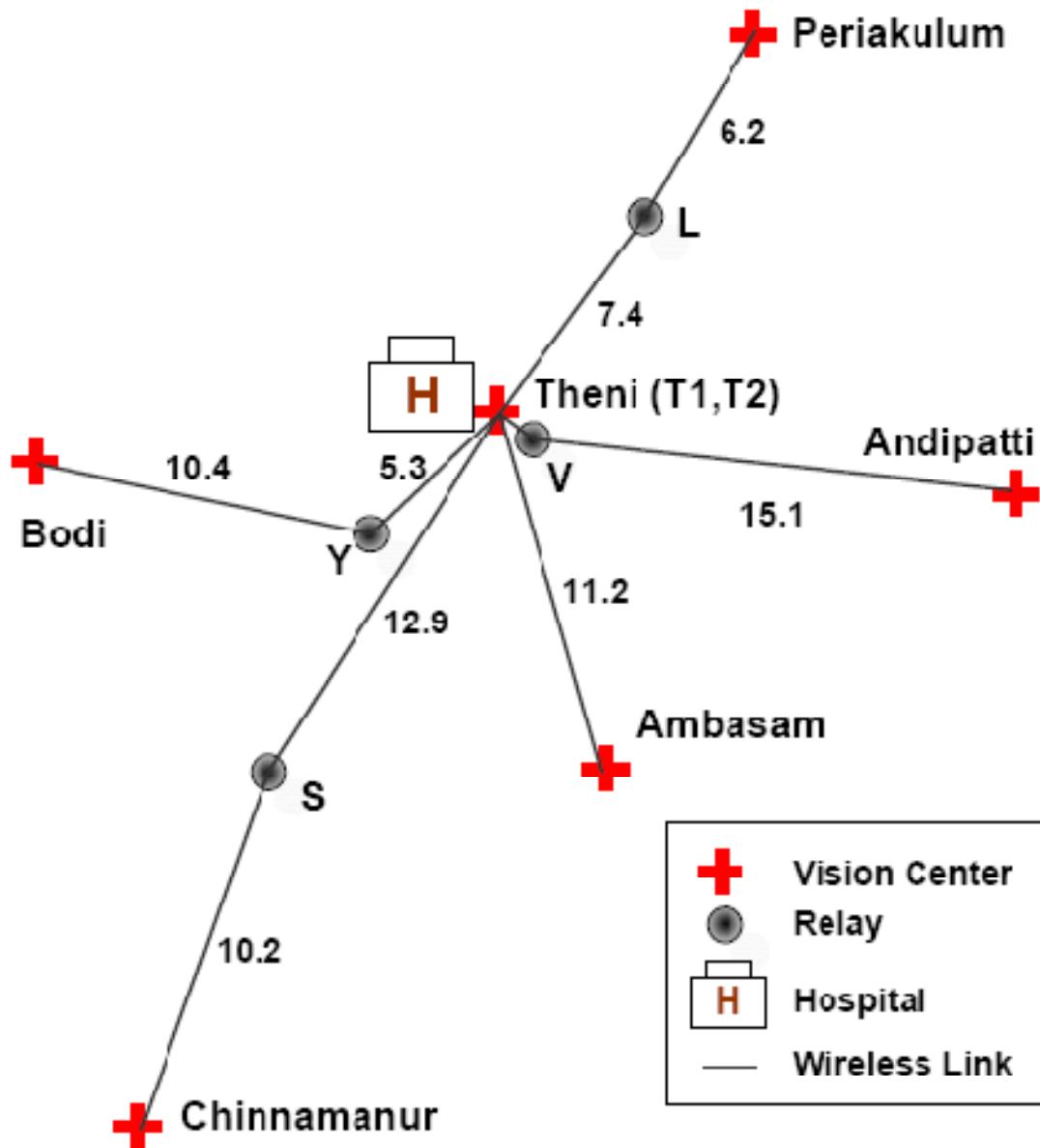
- North India
- Tibetan Community
- WiLD links + APs
- Links are 10 – 40 Kms long
- Achieve 4 – 5 Mbps per link
- VoIP + Internet
- 10,000 users



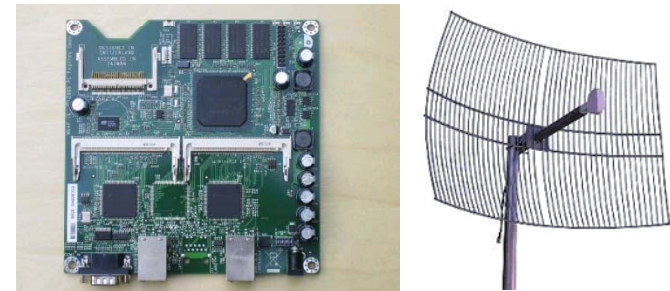
Routers used: (a) Linksys WRT54GL, (b) PC Engines Wrap Boards,

Costs: (a) \$50, (b) \$140

Aravind Eye Hospital Network



- South India
- Eye care, tele-ophthalmology
- All WiLD links
- Links 1 – 15 Kms long
- Achieve 4 – 5 Mbps per link
- Video-conferencing
- 5000 consultations/month



Routers used: PC Engines Wrap boards, 266 Mhz CPU, 512 MB
Cost: \$140

HW Faults

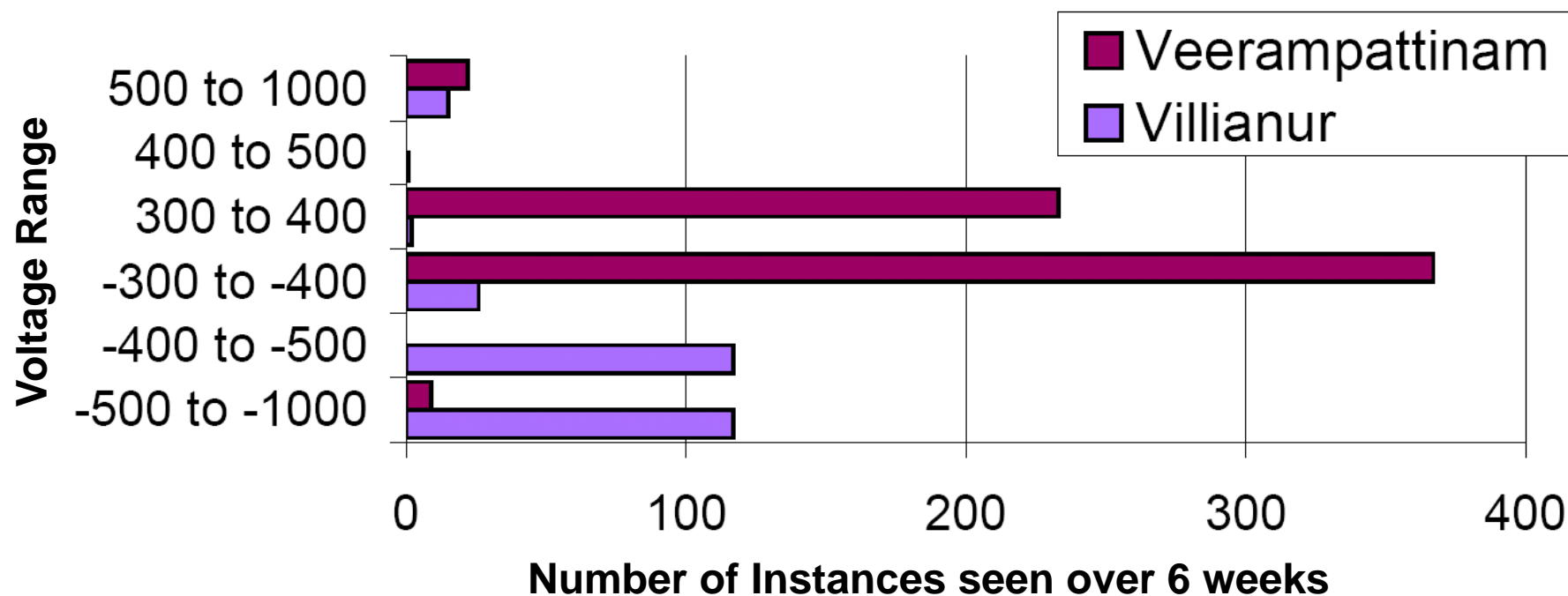
Hardware Faults at Aravind (in 2006)

Instances*	Description	Total Downtime
63	Router board not powered	63 days
7	Router powered but hung	10 days
21	Router powered but not connected to remote LAN (burned ethernet ports)	34 days
3	Router on, but wireless cards not transmitting (low voltage)	2 days
3	Router on, but pigtailed not connected	45 days
1	Router on, but antenna Line-of-Sight blocked	56 days

*Conservative Estimate

>90% of faults are power-related

Poor Quality Power



Spikes and Swells:

- Lost 50 power adapters
- Burned 30 PoE ports

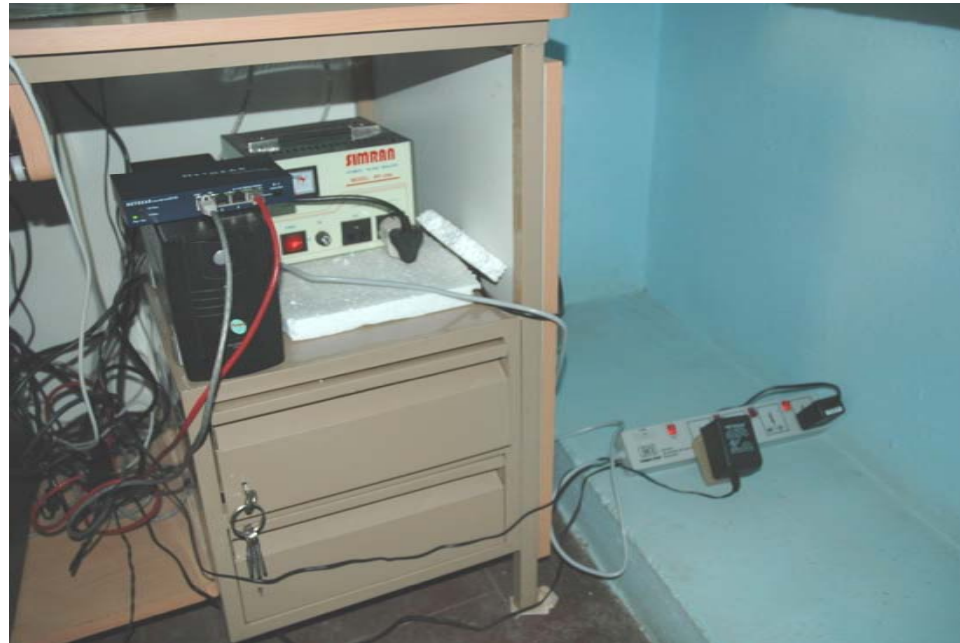
Low Voltages:

- Incomplete boots
- HW watchdog fails

Frequent Fluctuations:

- CF corruptions
- Battery Damage

What about UPS?



- “Affordable” UPS systems (\$100-\$300) are of *standby-type*
 - Primary source is grid
 - Secondary source is battery
 - Good quality power supplied only during outage!
 - 2006 fault episodes include use of UPS

Real Cost of Power

- Assume 7W
- Monthly Costs
 - Grid: \$0.25
 - UPS + Battery: \$6.08 (24X more!)
 - 50W Panel + Controller + Battery: \$8.24

Solutions

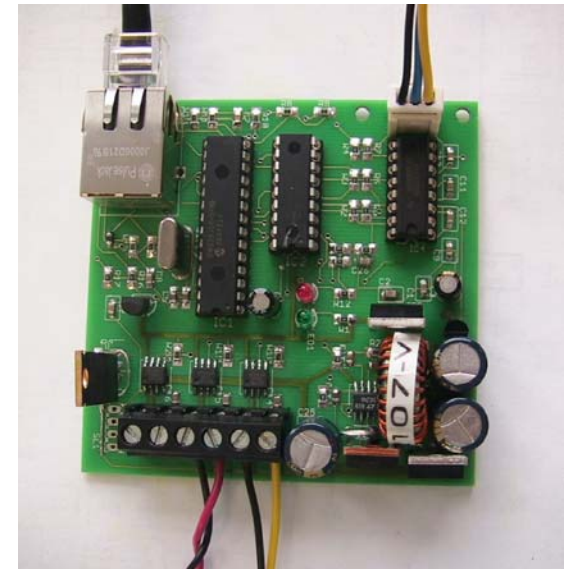
- Low Voltage Disconnect
- Low-cost Solar Power Controller

Low Voltage Disconnect

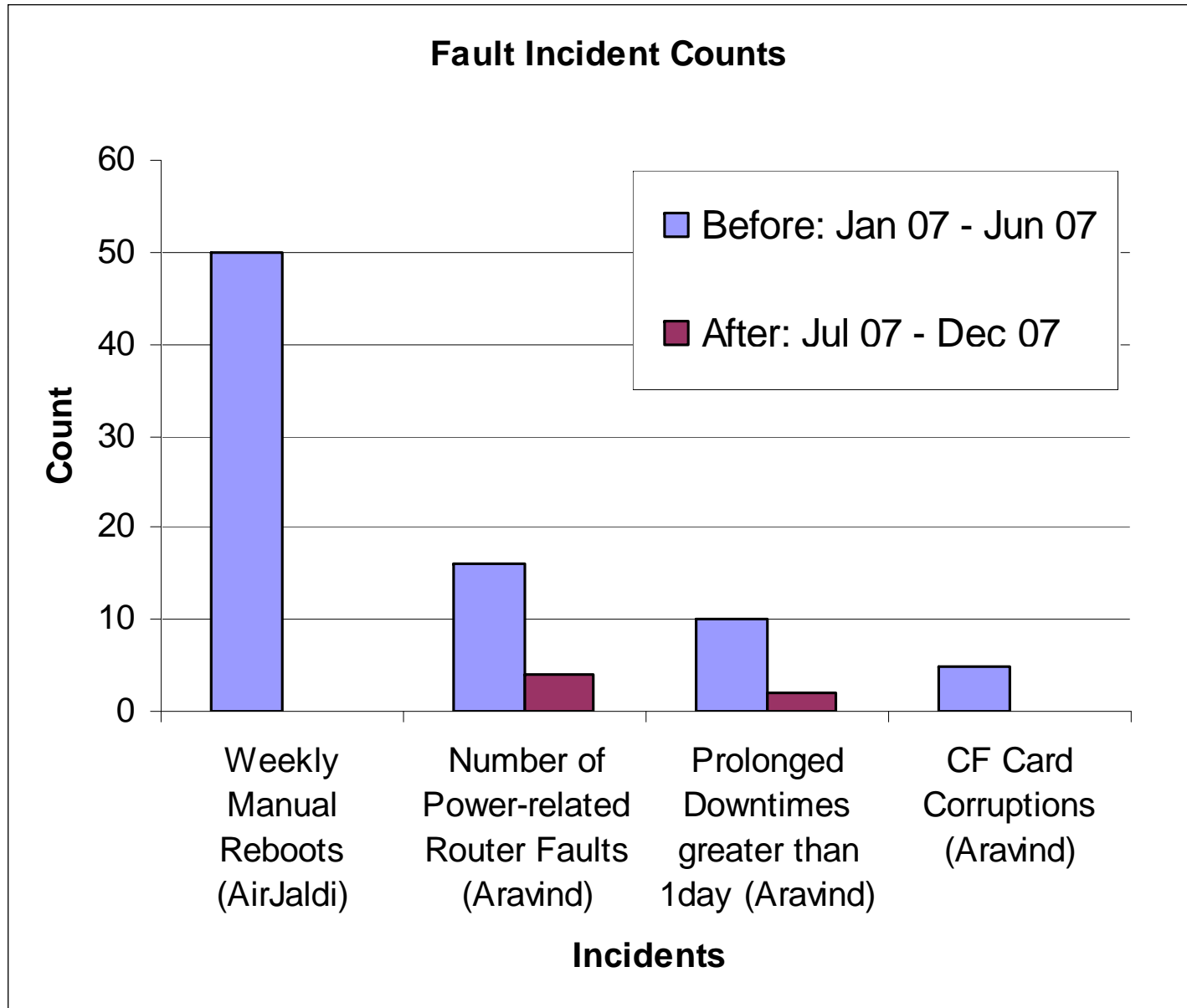
- Low Voltage Disconnect Circuit (LVD)
 - Disconnect load at low voltage
 - Prevent battery over-discharge and hung routers
 - Without LVDs, roughly 50 visits per week for manual reboots at AirJaldi
 - Off-the-shelf LVDs oscillate too much
 - Too many automatic reboots
 - We designed new LVD circuit with better delay
 - No more manual visits or reboots!

Low-cost Solar Power Controller

- Tackle spikes, swells and enable power at remote sites
- *Features*
 - PPT (peak power tracking) => 15% more power draw
 - LVD + trickle charging => Doubles battery life
 - Voltage regulator => No spikes and swells
 - Power-over-Ethernet => Remote Mgmt
 - \$70 (compared to \$300 commercial units)
- Have not lost any routers yet in 1 year



Operational Results



Thank you!



Resources:

- <http://tier.cs.berkeley.edu/wiki>
- sonesh@cs.berkeley.edu

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