Simplifying Fault Diagnosis in Locally Managed Rural WiFi Networks

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Joint work with Rabin Patra and Eric Brewer

Introduction

- Many rural wireless networks up in last few yrs
  - Aravind (India), CRCNet (New Zealand), etc.
- But operational maintenance is challenging!
- Long term support not guaranteed
- Training helps but high IT turnover
- Research agenda should expand to simplified diagnosis solutions

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Motivation

- Chances of hardware failure are higher because of poor power quality
- Node locations are hard to access
  - Many times trips turn out to be unnecessary
- Rural users are inexperienced initially
  - Rely on experts: longer downtimes and higher cost
- Goal: Reduce downtimes, costs, and build local capacity in managing the network

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Related Work in WiFi Diagnosis

- None for diagnosis in the context of rural WiLD (WiFi-enabled Long Distance) networks
- 802.11 Enterprise LAN Diagnosis
  - WiFi Profiler [1]
  - Jigsaw [2]
  - Different operating environments and different faults
- Recoverable Computing (e.g. RADS)
  - System designed to re-initialize and recover on reboot
  - But we are also trying to diagnose more than just software service errors, e.g. if antenna is misaligned or pigtail is not working, reboots don't' really help

[1] WiFiProfiler: Cooperative Diagnosis in Wireless LANs by ***Chandra et. al,*** Mobisys 2006

[2] Jigsaw: Solving the Puzze of Enterprise 802.11 Analysis by ***Cheng et. al***, Sigcomm 2006

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What do we need for diagnosis ?

- Identify data
  - Instantaneous and historical
  - Power, Node, Link, System
- Back Channel
  - Gather data and take action when primary link is down
- Independent Monitoring (and Repair)
  - Diagnose subsystems when main link is down
  - No dependency on system functioning

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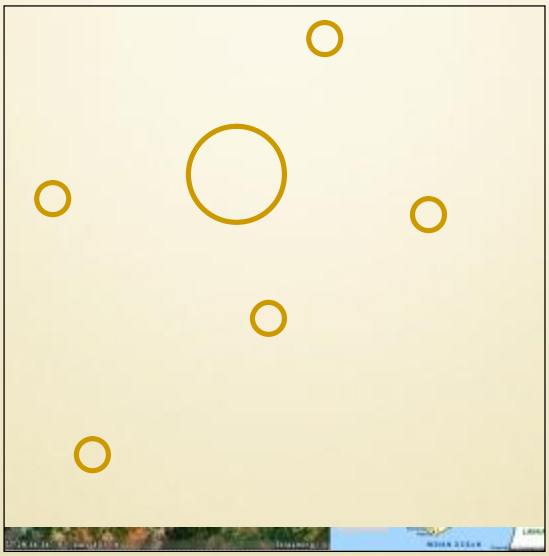
The Aravind Eye Hospital Network

Over 25,000 consultations since Jan 2006

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Real Faults from Aravind (1)

Hardware Faults (since Jan 2005)

Instances*	Description	Total Downtime
63	Router board not powered on (grid outage)	63 days
7	Router powered but hung	10 days
21	Router powered but not connected to remote LAN (burnt ethernet ports)	34 days
3	Router on, but wireless cards not transmitting (low voltage)	2 days
3	Router on, but pigtails not connected	45 days
3	Router on, but antenna misaligned	13 weeks

*Conservative Estimate

Undiagnosed: 41

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Real Faults from Aravind (2)

Software Faults (since Jan 2006)

Instances*	Description	Total Downtime
4	No default gateway specified	4 days
3	Wrong ESSID, channel, mode	3 days
2	Wrong IP address	2 days
2	Misconfigured routing	3 days

*Conservative Estimate

Undiagnosed: 41

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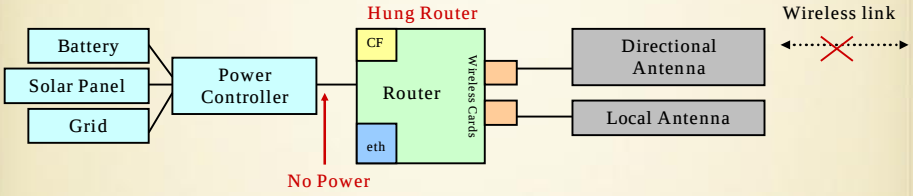
Scenario 1: Power/Hardware Problems



- How do we distinguish between these faults?
  - Power data, Board response data
- May or may not need site visit

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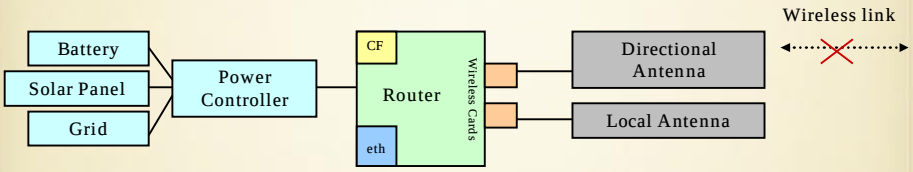
Scenario 2: Software Misconfiguration



- Reboot won't fix
  - Need additional actions
- No need for site visit

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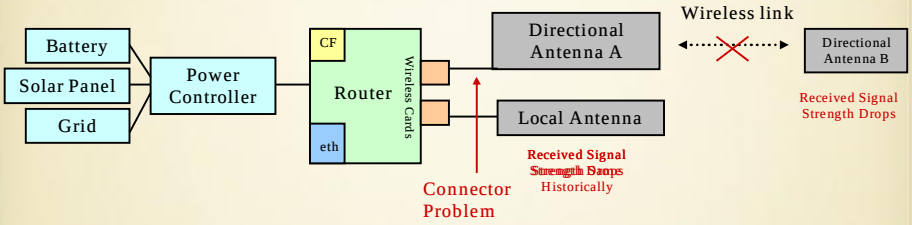
Scenario 3: Antenna Problems



- How do we distinguish ?
  - Signal strength measurements at both ends
- Reboots do not help
- Need site revisit

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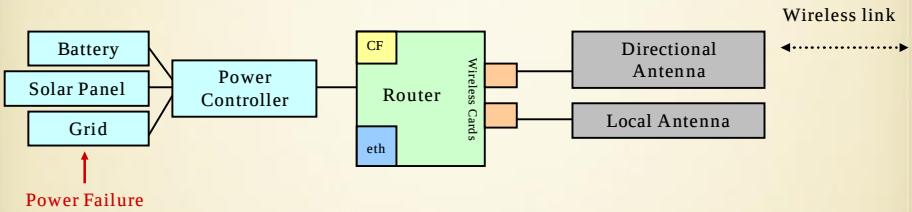
Scenario 4: Preemptive Diagnosis



- Monitor battery discharge cycles
- Plan replacement for next trip
- Also plan around failures
  - Predict remaining battery uptime for free

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Implementation

- Data Collection
  - PhoneHome
  - Delay Tolerant Networking (DTN) [1]
- Independent Back Channel
  - SMS backchannel
- Independent Monitoring (and Repair)
  - HW watchdog
  - Software watchdog
  - Cellphone device

[1] A Delay Tolerant Network Architecture for Challenged Internets by ***K. Fall,*** Sigcomm 2003

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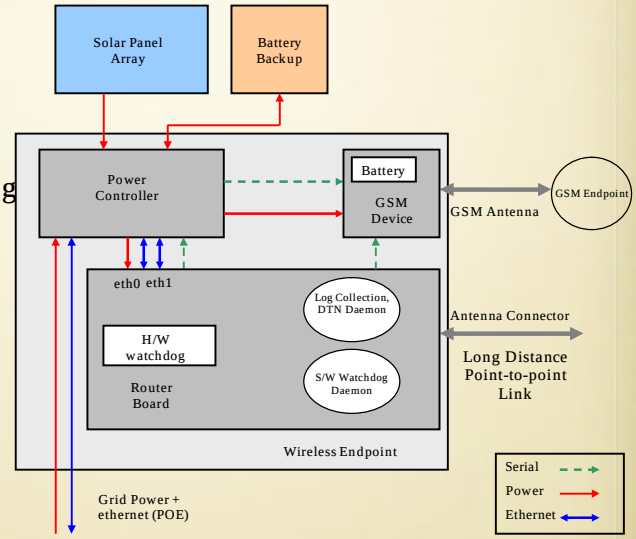
Node Architecture

- Hardware watchdog
- Software watchdog
- Log collection software
- Power Controller
- SMS Backchannel



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Current Status: Data Collection

Data being collected currently

Scope	Parameter
Node	CPU, disk, memory util, interrupts, voltage, temp, reboot logs, kernel messages, power controller data
Link	Traffic volume, signal strength, #retransmissions, #dropped packets, #overheard stations, #corrupted packets, packet loss, maximum bandwidth
System	Route changes, pairwise traffic volume, pairwise end-to-end delay and maximum throughput

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Current Status: Data Collection

- PhoneHome
  - Connections only able to be initiated from inside the network
  - Open SSH tunnels to US server
  - Have back channel at main node
- DTN (Delay Tolerant Networking)
  - Store and forward overlay network
  - User persistent storage to ensure delivery after link recovers
  - Each node runs DTN demon

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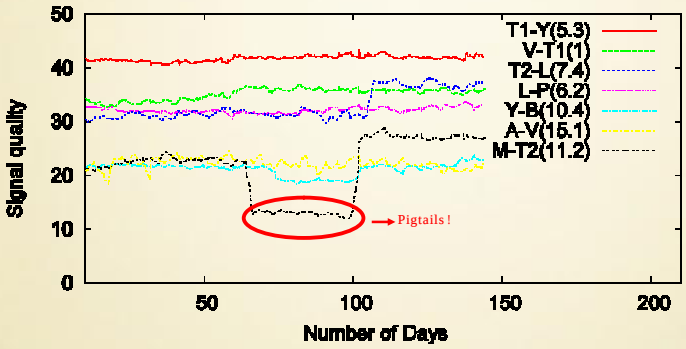
Current Status: Data Collection



- Other example data
  - One relay node rebooted 515 times in ~150 days
  - If power data, could see if power was the problem at relay

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Current Status: Power Controller

- Features
  - Combines grid, solar, battery input
  - Maximum power point tracking
  - Status reporting through Ethernet and Serial
  - Can query and reboot the router

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Future Work

- Add Cellphone
  - SMS-based Back channel
    - 160-byte (40 integer parameters)
  - Independent Monitor
    - Communicate over serial with board and controller
- Deployment at Aravind by end of 2007

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Thank You!

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

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Backup Slides

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Goals

- Ultimately, reduce the need for CS PhD students or other such “experts” to go there
  - Prevent elongated downtimes
  - High cost: last year alone, I went 5 times ($10K in tickets only!)
- Pinpoint faults for quicker fixes: reduce downtime
- Reduce unnecessary or blind travel
- Provide ability to plan around faults
- Educational benefit over time (capacity building); demystify faults to inexperienced users

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What is a Fault ?

- "The link is down!"
  - Some nodes cannot be reached
  - Generally an email (many times sent after few days)
- Hard to find the root cause
  - Any component could have failed

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Conclusions

- Separate

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One Extreme Example

- Downtime: 2 months!

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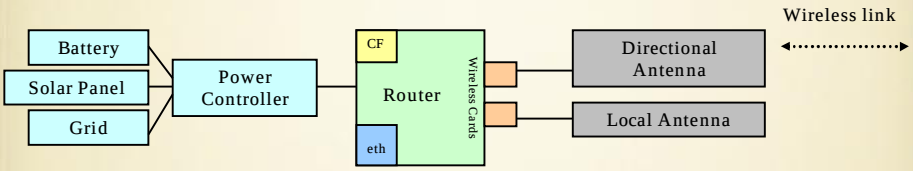
What does a WiLD link look like ?



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Requirements Distilled

- History is a valuable diagnosis tool
  - Monitor status
  - Compare with expected behavior
  - Possibly predict using simple techniques
- Out-of-band access to various link components
  - Hardware
  - Software
  - Back Channel

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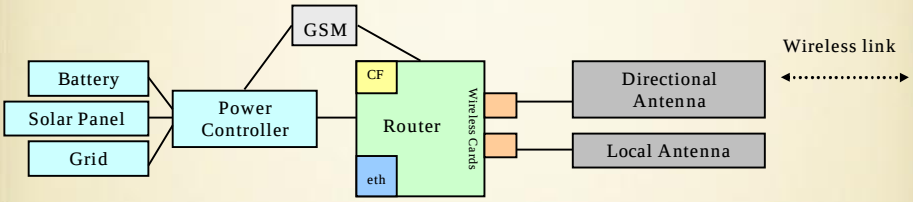
How Does it All Come Together ?



- Walk down a decision tree
  - Can do binary or smarter searches
- Package up status info
- Send over the back channel
- Take local action if possible (reboot)

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Implementation Details to Consider

- SMS to router protocol
  - What phones or other devices to choose ?
  - How much programmability required ?
  - Polling interface ?
  - How much can be packed into SMS message for status ?
    - Can we do routine log collection over SMS ?
  - Transport protocol over SMS ?

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