Experiences with WiFi for Rural Internet in India

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Outline

- Why WiFi for rural Internet?
- Two projects: Digital Gangetic Plains, Ashwini
- Network planning
- MAC protocols: P2P & P2MP links
- Performance studies on long-distance links
- Power optimization: Wake-on-WLAN

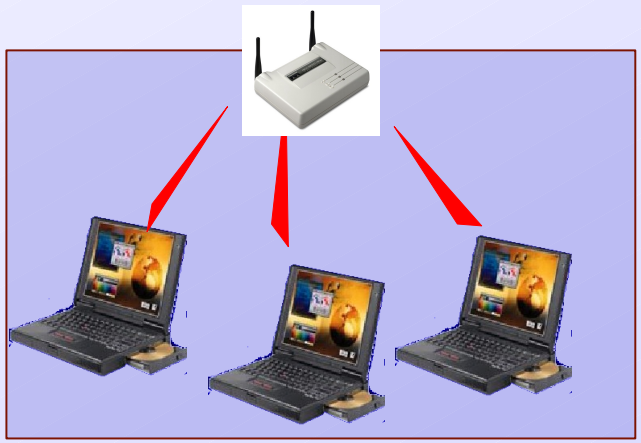
WiFi for Rural Networking

Cost of land-line telephony: $400 per line --> $200 per line

400 million lines for India ==> $80 billion

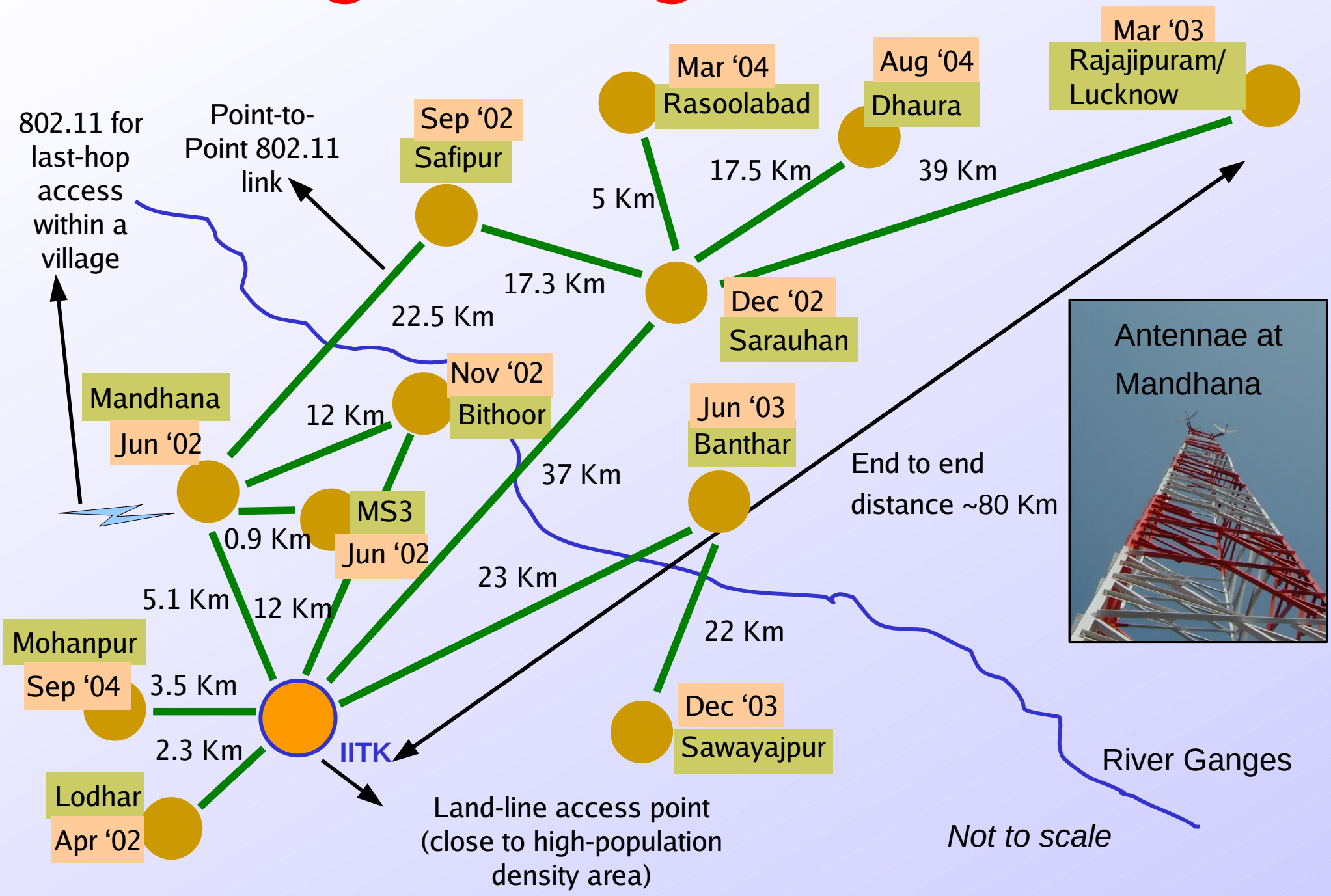
Cellular technology is *value-priced*
(expensive for rural deployment)

WiMAX (IEEE 802.16) yet to hit the market
Unclear if it will be inexpensive enough for rural areas

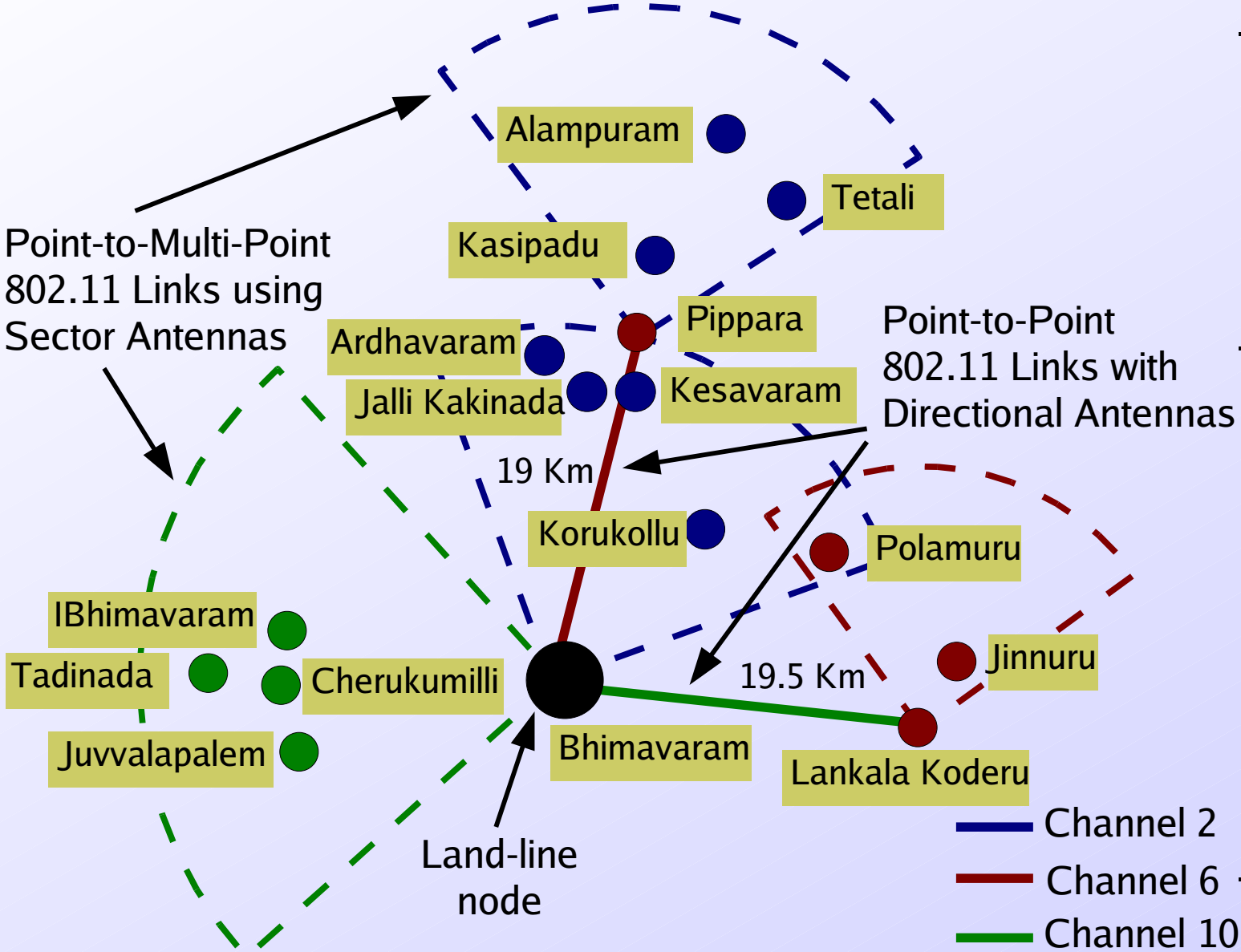


In contrast: WiFi equipment *cost-priced*
Rs 2-5K per WiFi radio
Inexpensive enough for rural deployment

Digital Gangetic Plains



Ashwini



- Byrraju foundation, Andhra Pradesh
- Video-based services: distance-education, tele-health, agricultural advice
- 17 nodes to be added

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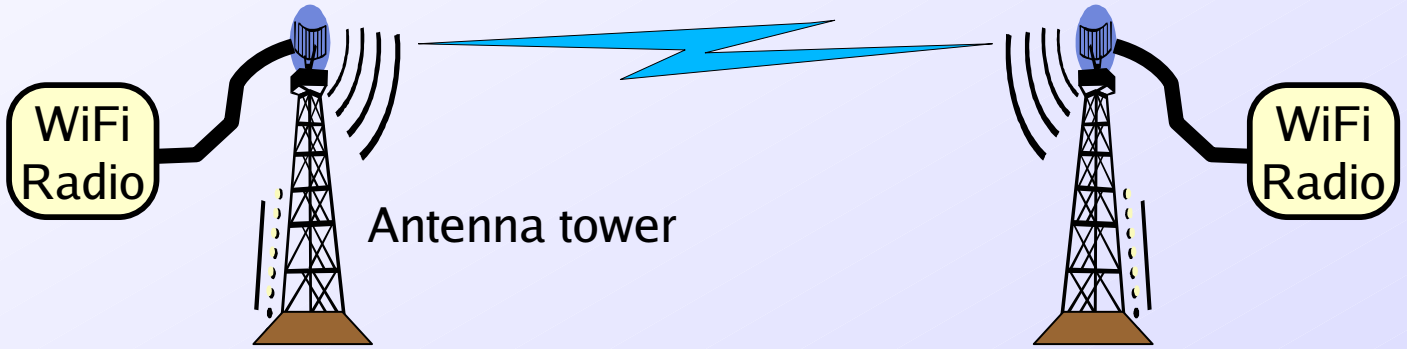
Network Planning

- WiFi needs line-of-sight for long-distances



- Tower costs are high

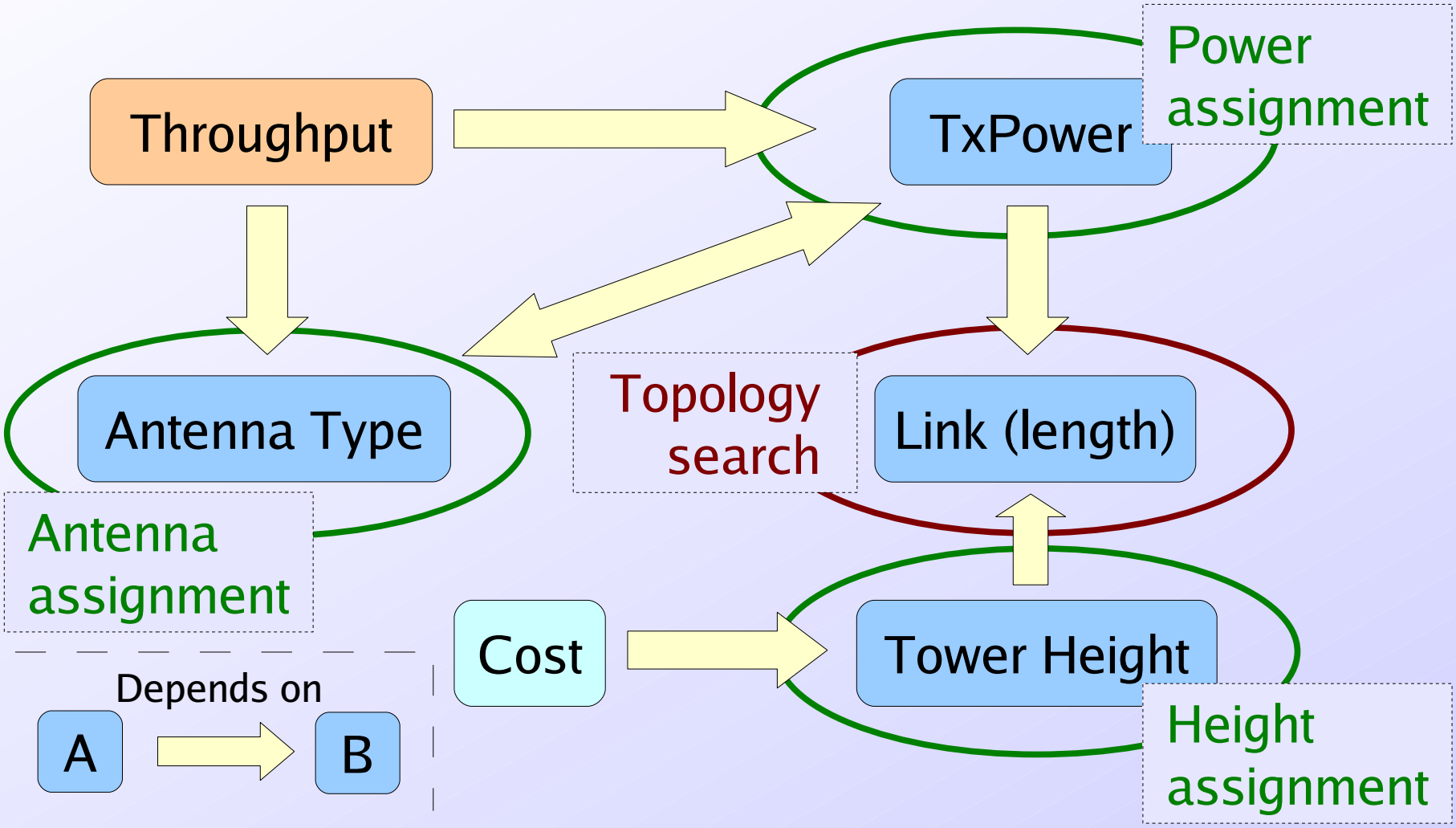
Tower/mast height (m)	10	15	21	24	27	30	45
Cost	$100.00	$150.00	$800.00	$950.00	$1,100.00	$1,850.00	$5,000.00

- Implication: Network planning necessary

Aspects of Network Planning

- Goals: minimize cost, adequate throughput
- Inter-dependent parameters:
  - Tower heights
  - Network topology
  - Antenna types
  - Transmit powers

Network Planning: Approach



Further reference: Sayandeep Sen, “Topology Planning for Long Distance Wireless Mesh Networks”, Master's thesis, IIT-Kanpur, May 2006.

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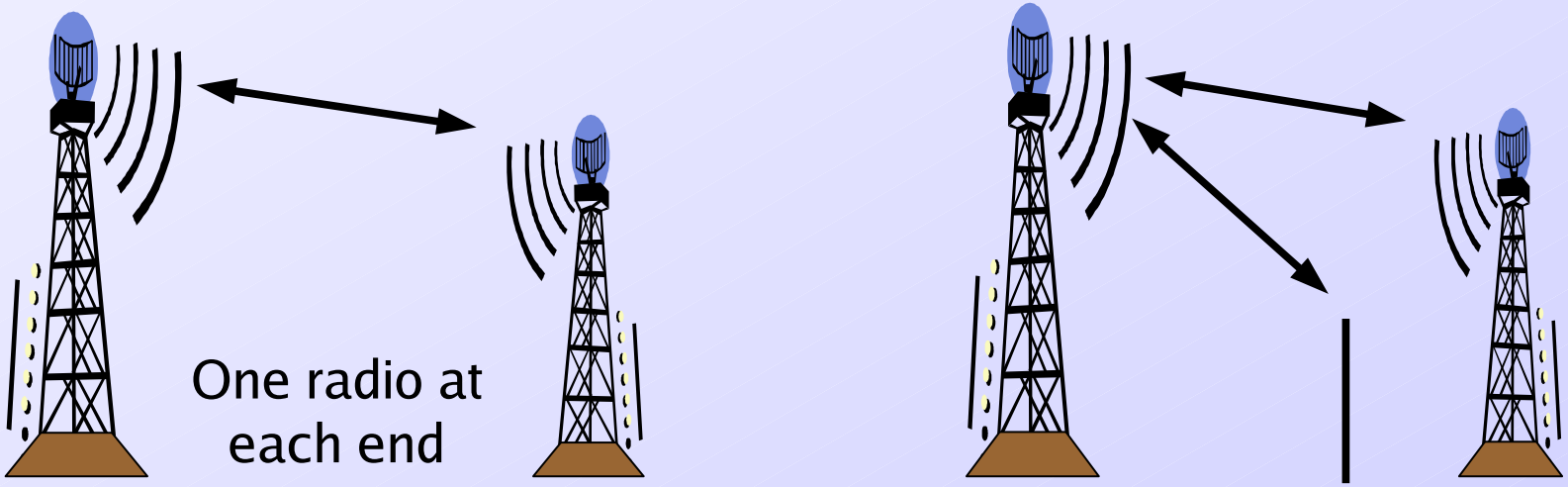
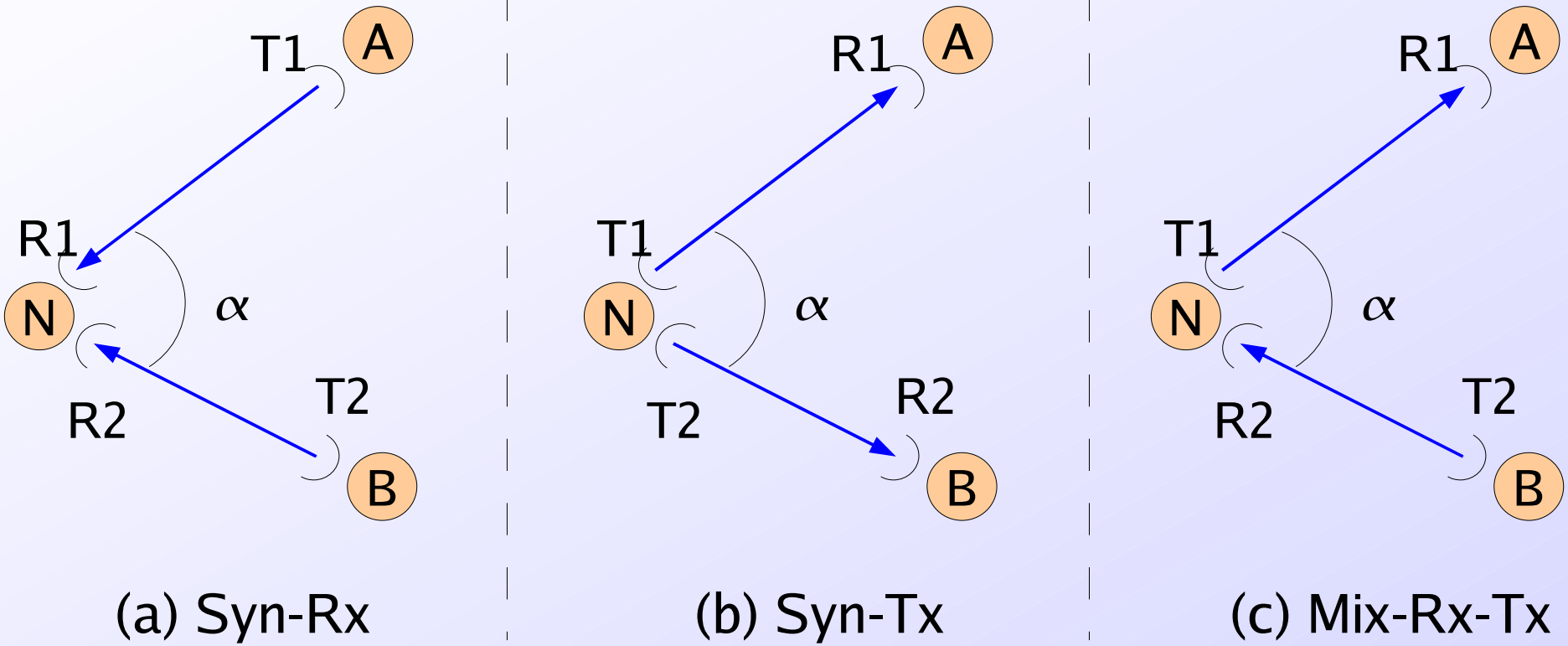
MAC Protocol

- 802.11's CSMA/CA unsuitable
  - Timing parameters need to be made larger
  - Arbitrary contention resolution unnecessary
- P2P versus P2MP links



P2P Links: 2P MAC Protocol



Exposed interface problem within a node:

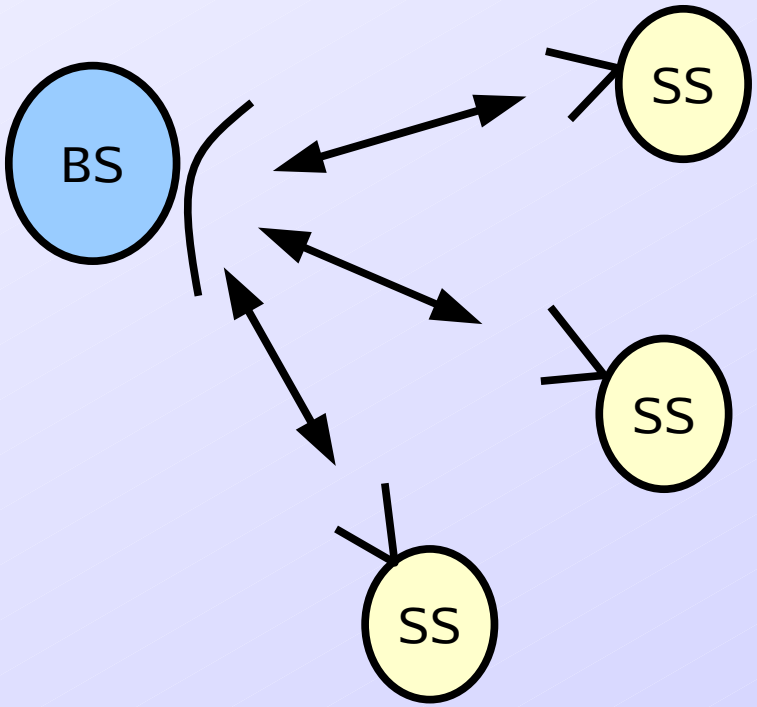
CSMA/CA: only one link operation per node

Problems: (a) Immediate ACK, (2) CS back-off

Further reference: Bhaskaran Raman and Kameswari Chebrolu, “Design and Evaluation of a new MAC Protocol for Long-Distance 802.11 Mesh Networks”, MOBICOM, Aug/Sep 2005.

P2MP Links: SRAWAN

- SRAWAN: Sectorized Rural Access Wide Area Network
  - Simplified WiMAX MAC
  - On 802.11 PHY
  - Single-sector operation
- WiFiRe: multi-sector operation



Further reference: Pavan Kumar, “Design, Implementation, and Evaluation of new MAC Protocols for Long Distance 802.11 Networks”, Master's thesis, IIT-Kanpur, May 2006.

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Long-Distance Link Performance: Questions

- What is the effect of received signal strength on packet error rate?
- What is the effect of packet size and transmit rate on packet error rate?
- What is the maximum achievable application throughput?
- What is the effect of interference?

Long-Distance Link Performance: Questions

- What is the effect of weather on link performance?
- Is there time correlation of packet errors? If so, at what granularity?
- What is the effect of MAC ACK timeouts on application throughput?

Conclusion from Performance Study

- Long distance links can be planned well for predictable performance
- Interference can cause drastic reduction in performance
- Beware of bottlenecks other than wireless interface

Further reference: Kameswari Chebrolu, Bhaskaran Raman and Sayandeep Sen, “Long-Distance 802.11b Links: Performance Measurements and Experience”, MOBICOM, Aug/Sep 2006. *To Appear.*

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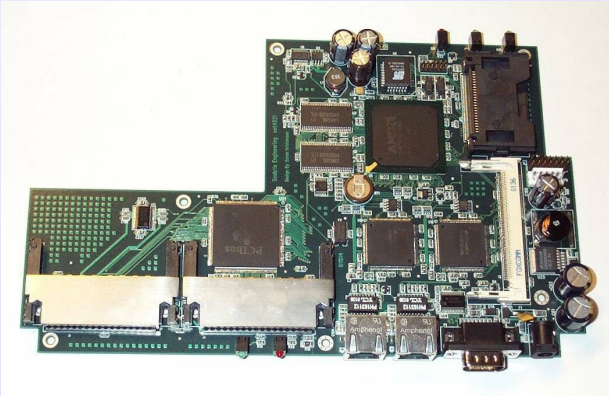
Background & Motivation

- Power consumption of Soekris

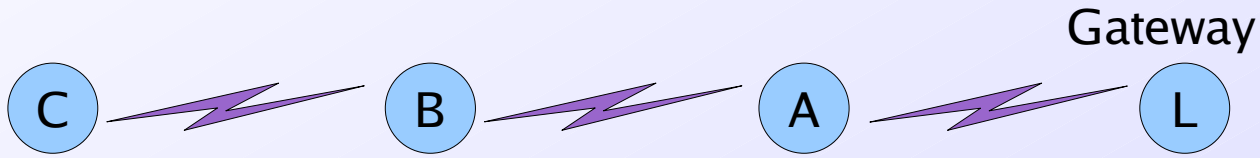
No Card Present	4.75 W
Card Present, No Transfer	4.89 W
Soekris Receiving	5.31 W
Soekris Transmitting	6.24W



  - Overall power consumption dominated by Soekris
- Power can be conserved by
  - Turning off equipment when link idle
  - Turn on equipment when connectivity is desired

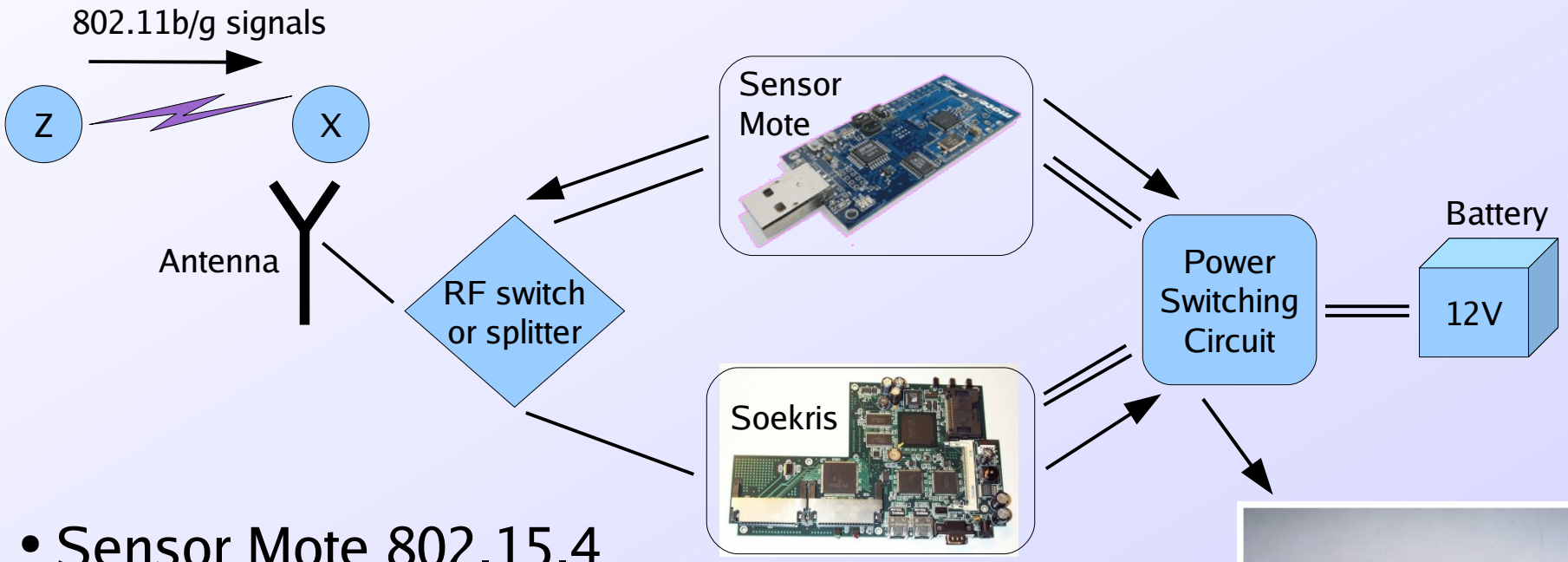
Challenge

- Multi-hop Configuration

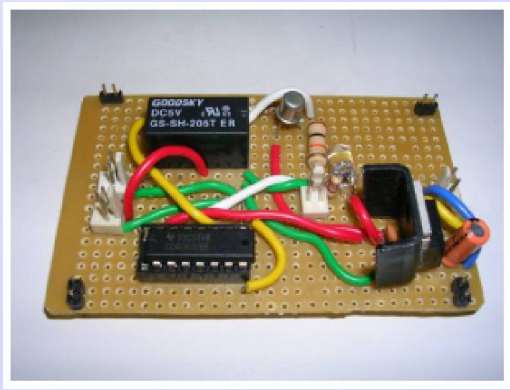


- No support for Wake-on-LAN feature
  - Neither WLAN card nor Soekris support this feature

WAKE-on-WLAN Architecture



- Sensor Mote 802.15.4
- CCA Mode 1:
  - Clear channel when received energy is below threshold
- RSSI.CCA_THR, 1db, default = -77dbm
- FSCTRL.FREQ, 1Mhz, default=2.405MHz



Outdoor Validation

Tx Power (IITK)	Rx Power (Mohanpur)	Soekris State
Case 1: CCA = -74 dbm		
20 dbm	-62 dbm	Yes
10 dbm	-72 dbm	Yes
0 dbm	-84 dbm	No
-2 dbm	-85 dbm	No
Case 2: CCA = -90 dbm		
20 dbm	-62 dbm	Yes
10 dbm	-72 dbm	Yes
0 dbm	-84 dbm	Yes
-2 dbm	-85 dbm	Yes

Further reference: Nilesh Mishra, Kameswari Chebrolu, Bhaskaran Raman and Abhinav Pathak, “Wake-on-WLAN”, WWW, May 2006.

Conclusion

- WiFi a potential low-cost technology for rural broadband
- Two projects: DGP, Ashwini
- Various network planning, protocol, performance, power optimization issues addressed
- Several open issues, to be thrashed out with further experience from deployment
- Papers, presentations, reports:
  - http://www.cse.iitk.ac.in/users/braman/dgp.html