The 2P MAC for Rural WiFi Networks

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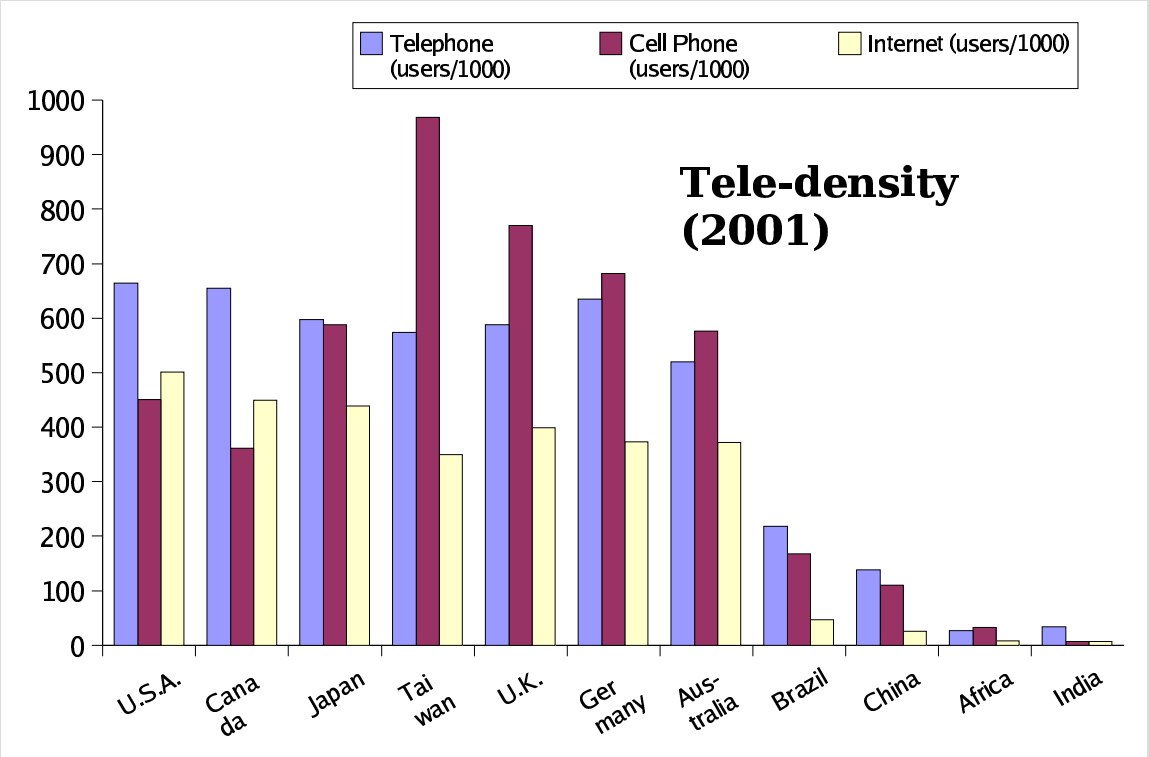
Presentation at Cutting-Edge, 08 April 2005

Outline

- Why 802.11 WiFi for Rural Internet?
- A Cost Analysis, Network Architecture
- Performance of the 802.11 CSMA/CA MAC
- The 2P MAC
- Conclusions

Communication Revolution: Myth or Reality?

- Depends on who you ask...
- > 75% of the world yet to see any communication
- Cell-phone revolution in India: restricted to the metros

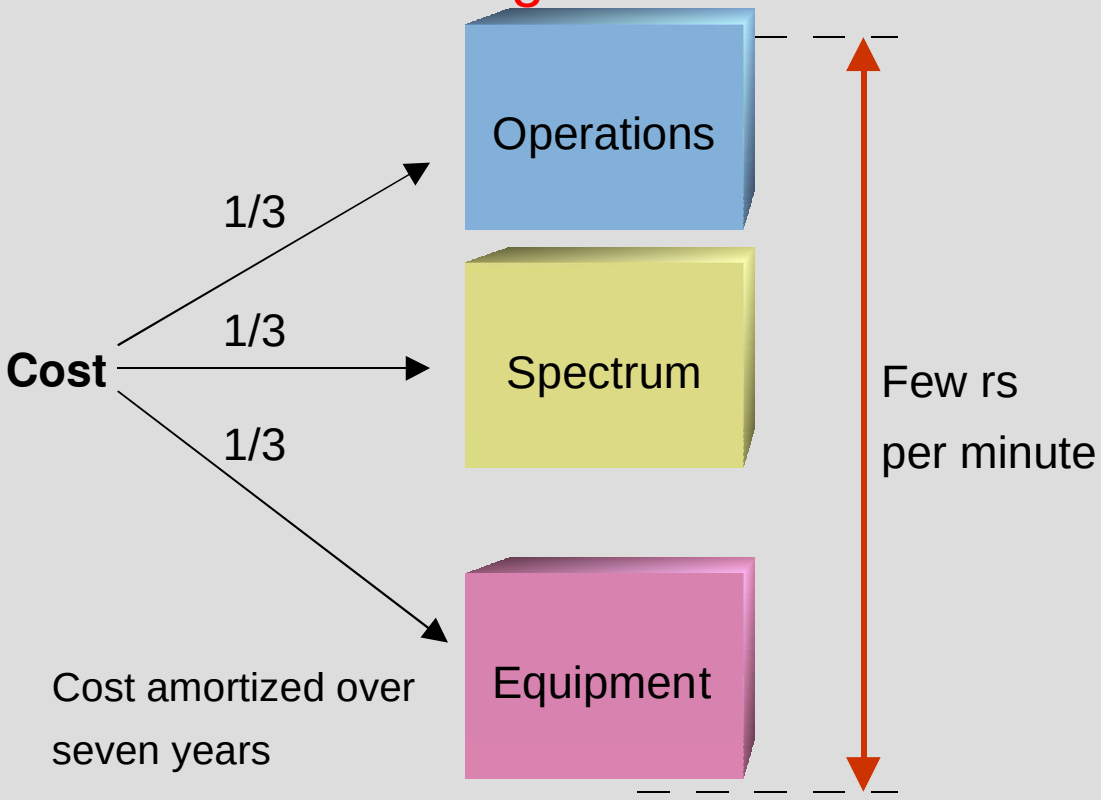


What are the Barriers?

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

400 million lines ==> $80 billion

Value Pricing of Cellular Technology

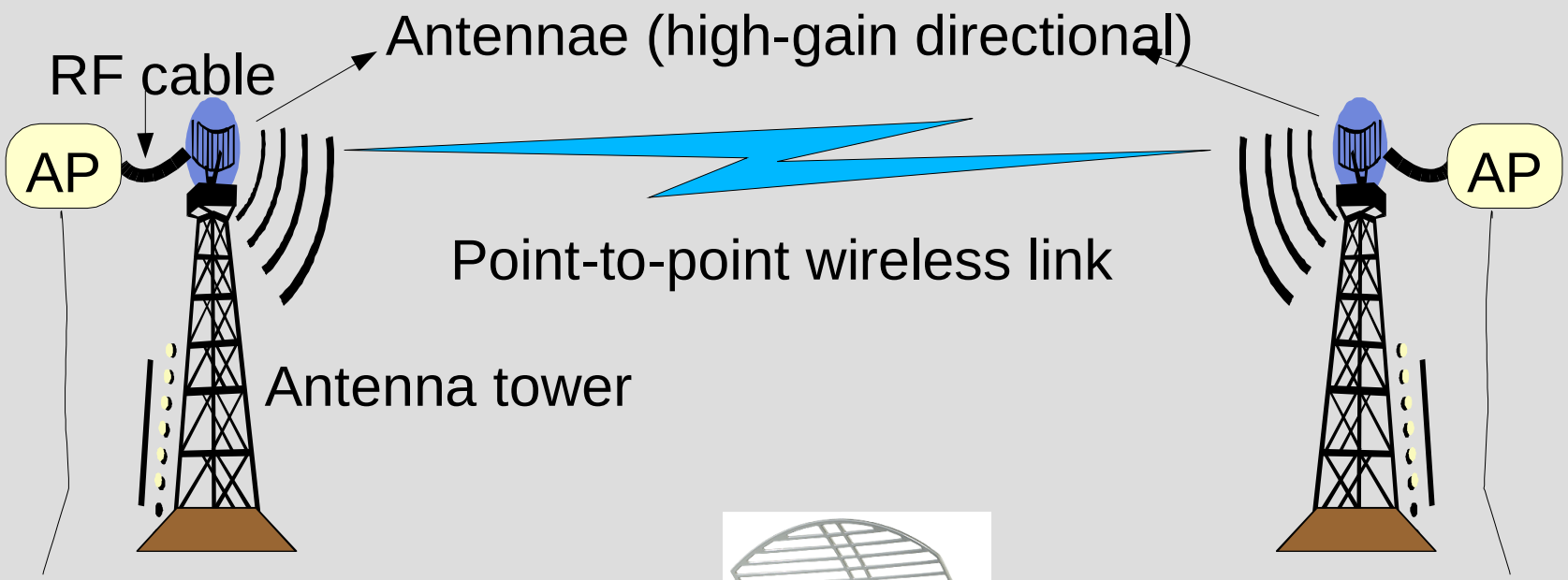


People in developed economies, and metros are willing to pay this price because voice is a very high value application

WiFi: A Cost-Effective Technology

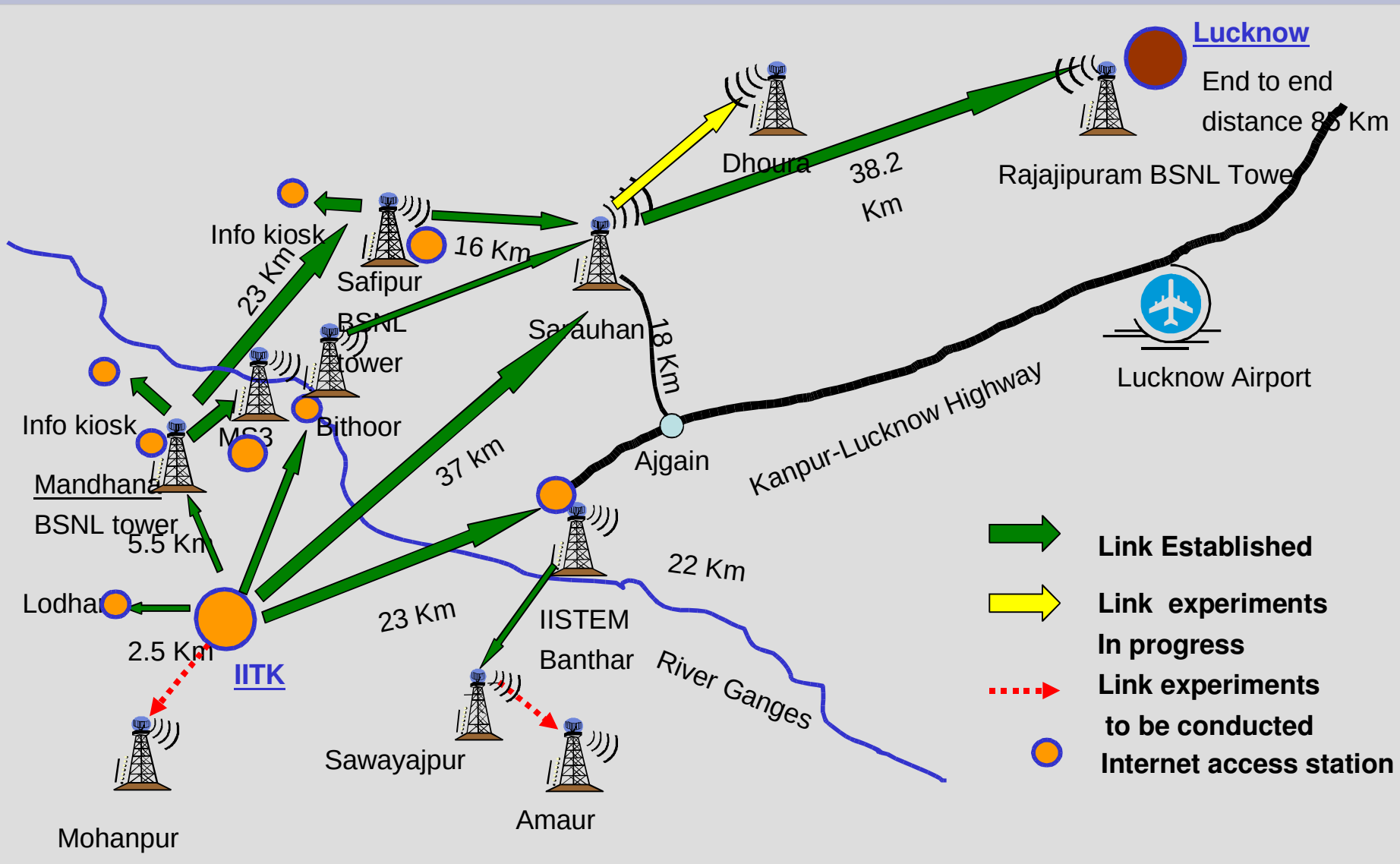
- Equipment: cost priced
  - Open, inter-operable standard
  - Competitive mass production
  - Chip-sets: $25-30, Access-Points: $120-700, PCMCIA cards: $60-110
- Spectrum is free!!!

How to Use WiFi for Rural Internet?



Ethernet cable (to hub/PC)

Digital Gangetic Plains Testbed



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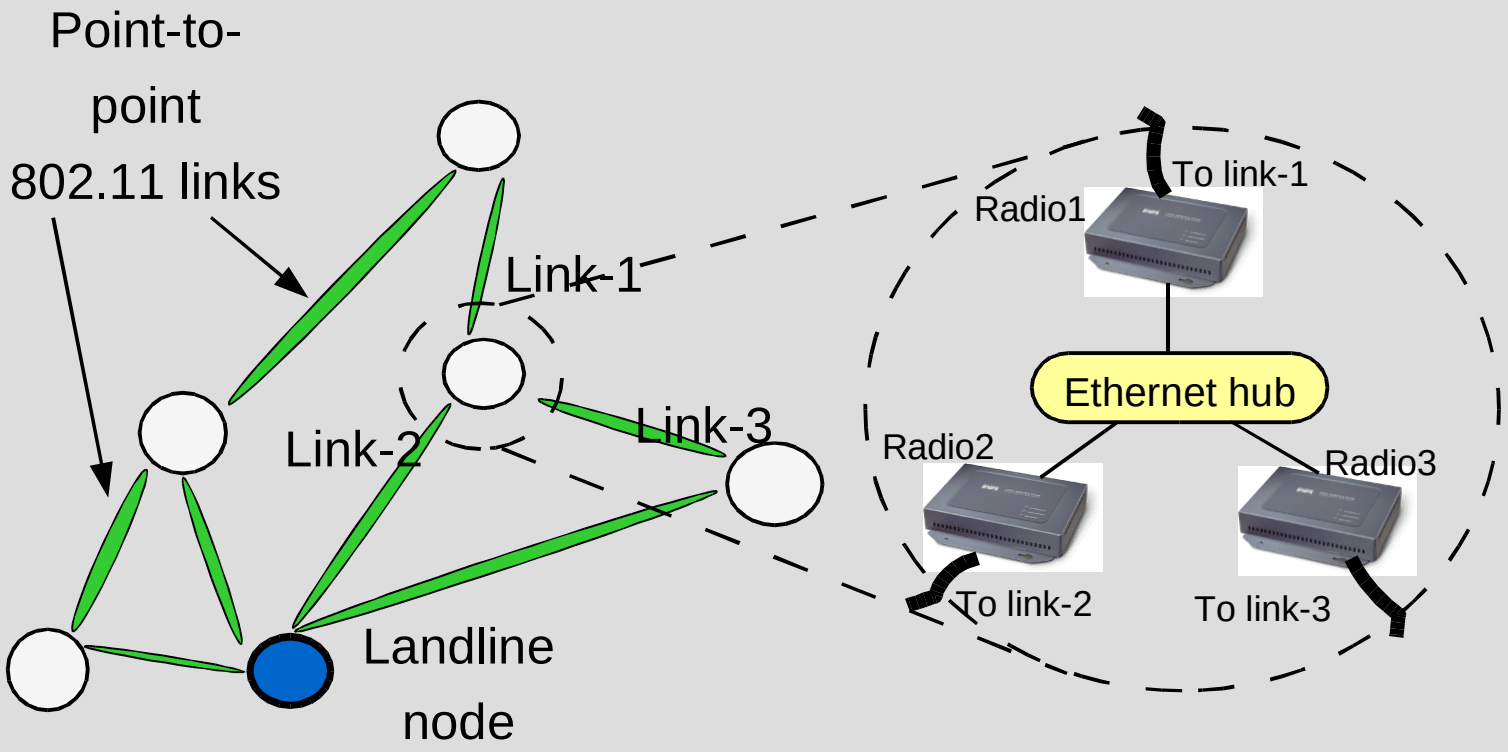
What are the Costs?

Antenna tower (30m)	Rs. 70K
802.11 devices	Rs. 4K

- Tower cost is dominant
- Alright to have multiple 802.11 radios per location in the network

Network Architecture



- A generic mesh network
  - Multiple radios per node
  - One directional antenna per-link

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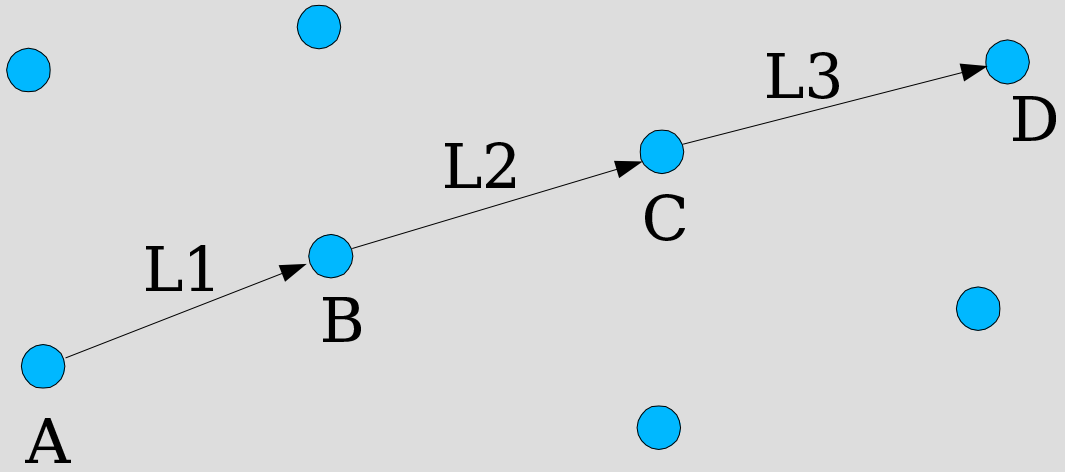
The 802.11 CSMA/CA MAC

- Designed for heavy reuse (in the free spectrum)
- Carrier-Sense Multiple Access with Collision Avoidance
  - Good for situations of random contention
  - For example, several users in a room

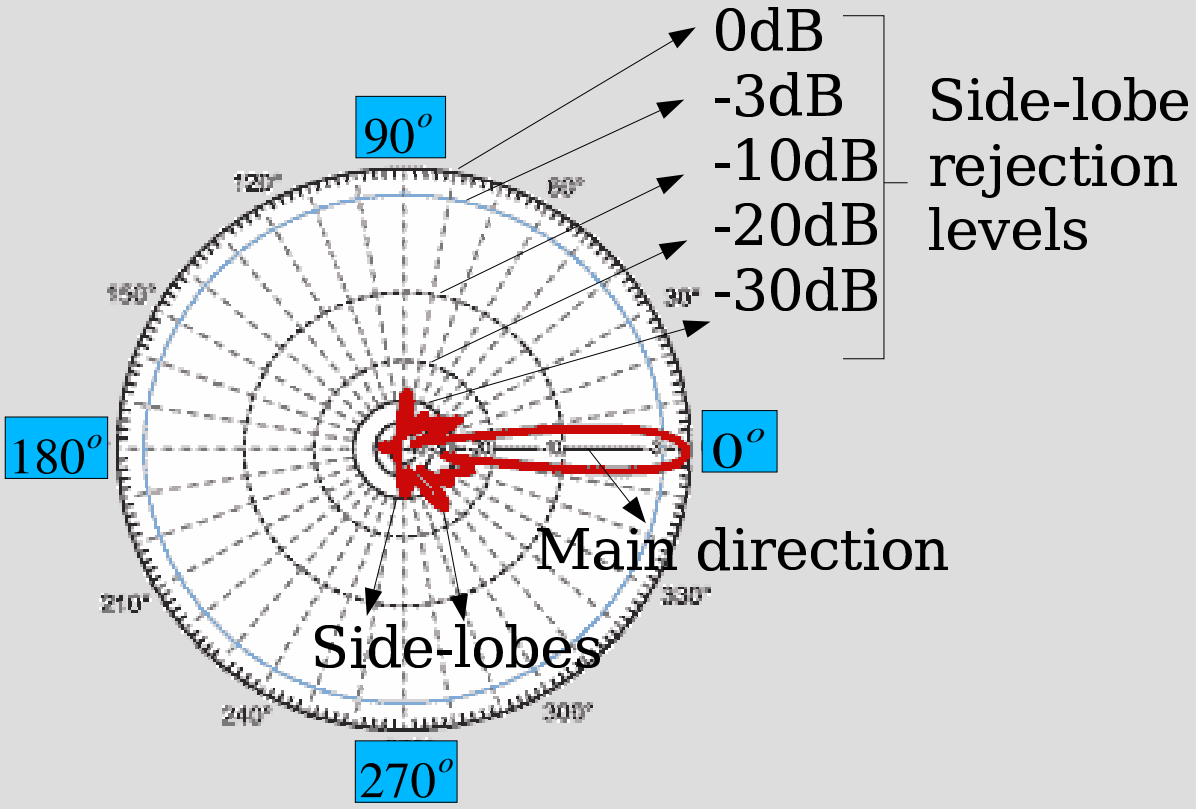
802.11 in a Multi-Hop Setting

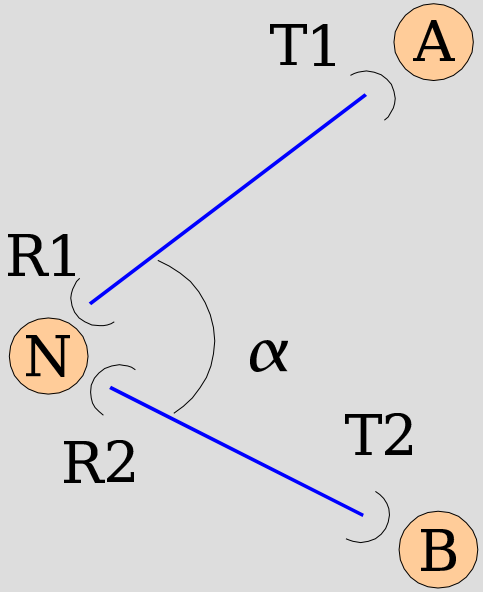


RTS/CTS used?	1-hop (Mbps)	2-hop (Mbps)	3-hop (Mbps)
Yes	4.5	2.2	1.5
No	6.1	3	2

Exposed node problem

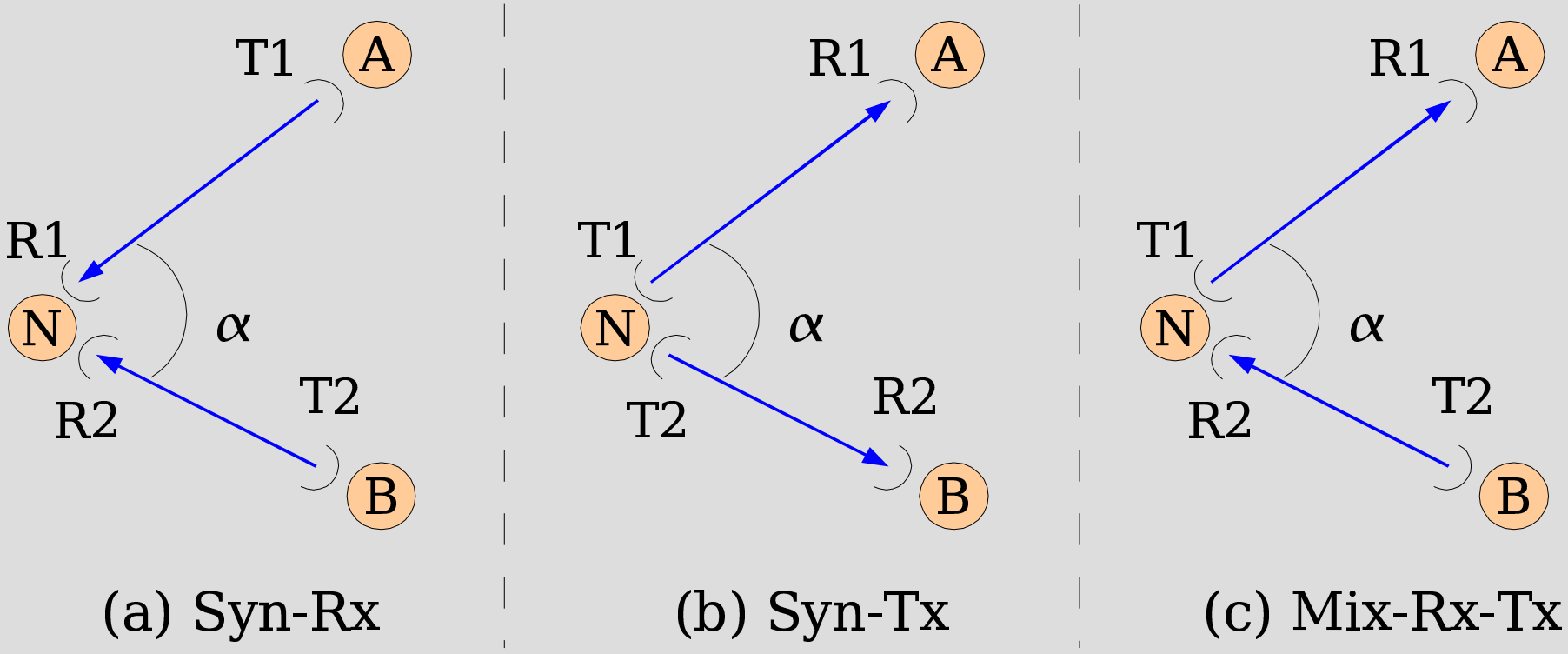
Multiple Interfaces, Directional Antennae





Syn-Rx

The Exposed Interface Problem



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SynOp: SynRx + SynTx

- Links at a node operating simultaneously, synchronously (on the same channel)
- Is this feasible? Yes, under certain conditions

$$P_{R_1} - (P_{R_2} - SL_\alpha) \geqslant SIR_{reqd}$$

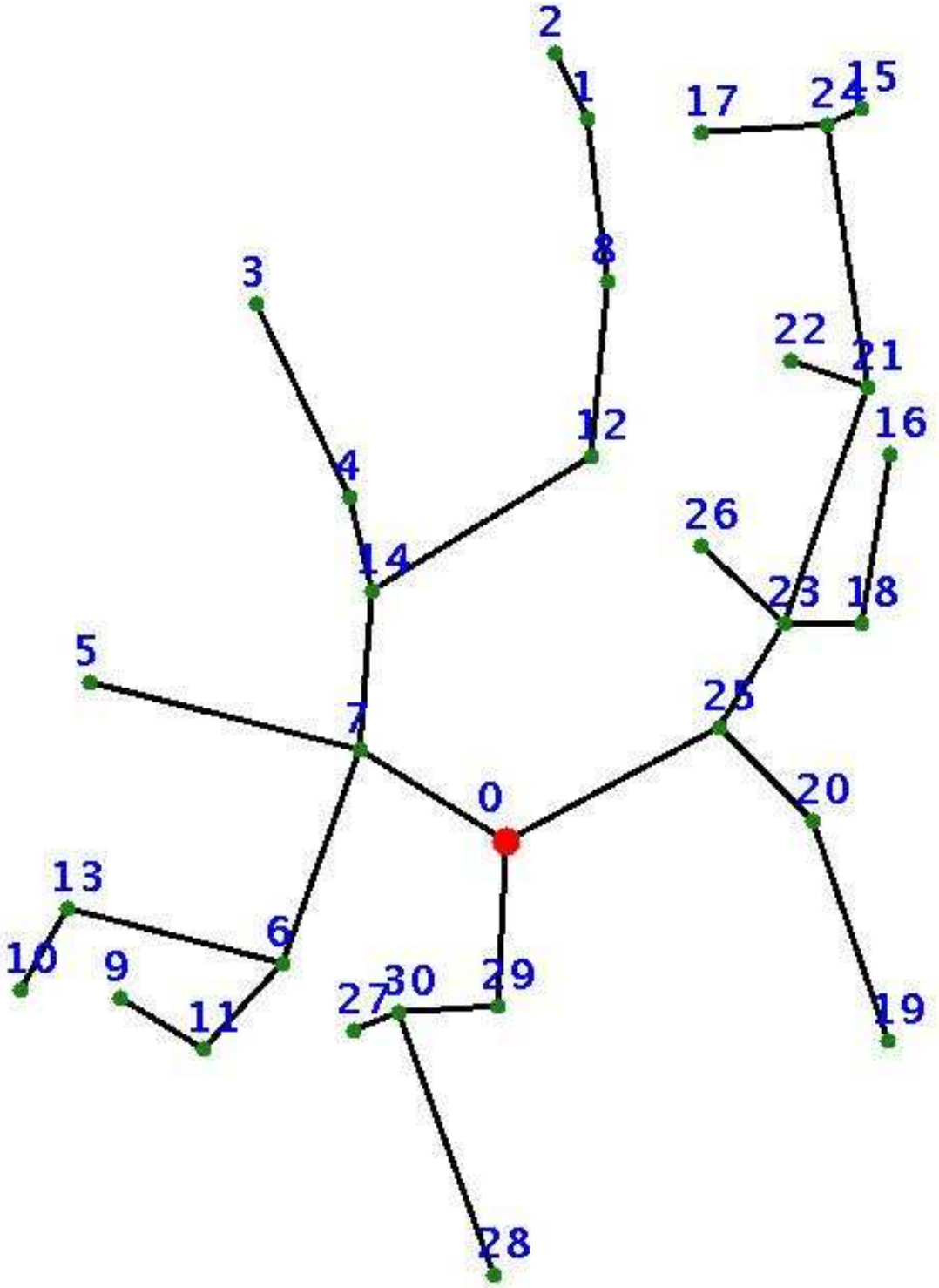
$$P_{R_2} - P_{R_1} \leqslant SL_\alpha - SIR_{reqd}$$

$$P_{R_1} - P_{R_2} \leqslant SL_\alpha - SIR_{reqd}$$

$$\left| P_{R_1} - P_{R_2} \right| \leqslant SL_\alpha - SIR_{reqd}$$

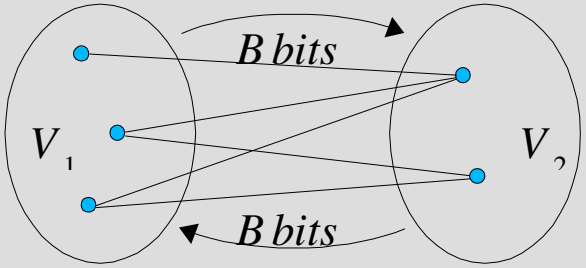
SynOp Feasibility

- Write a set of linear equations
  - Powers of transmission are variables
  - Solve the linear equations
  - Feasible ==> synop possible throughout the network
- Feasible for many practical cases



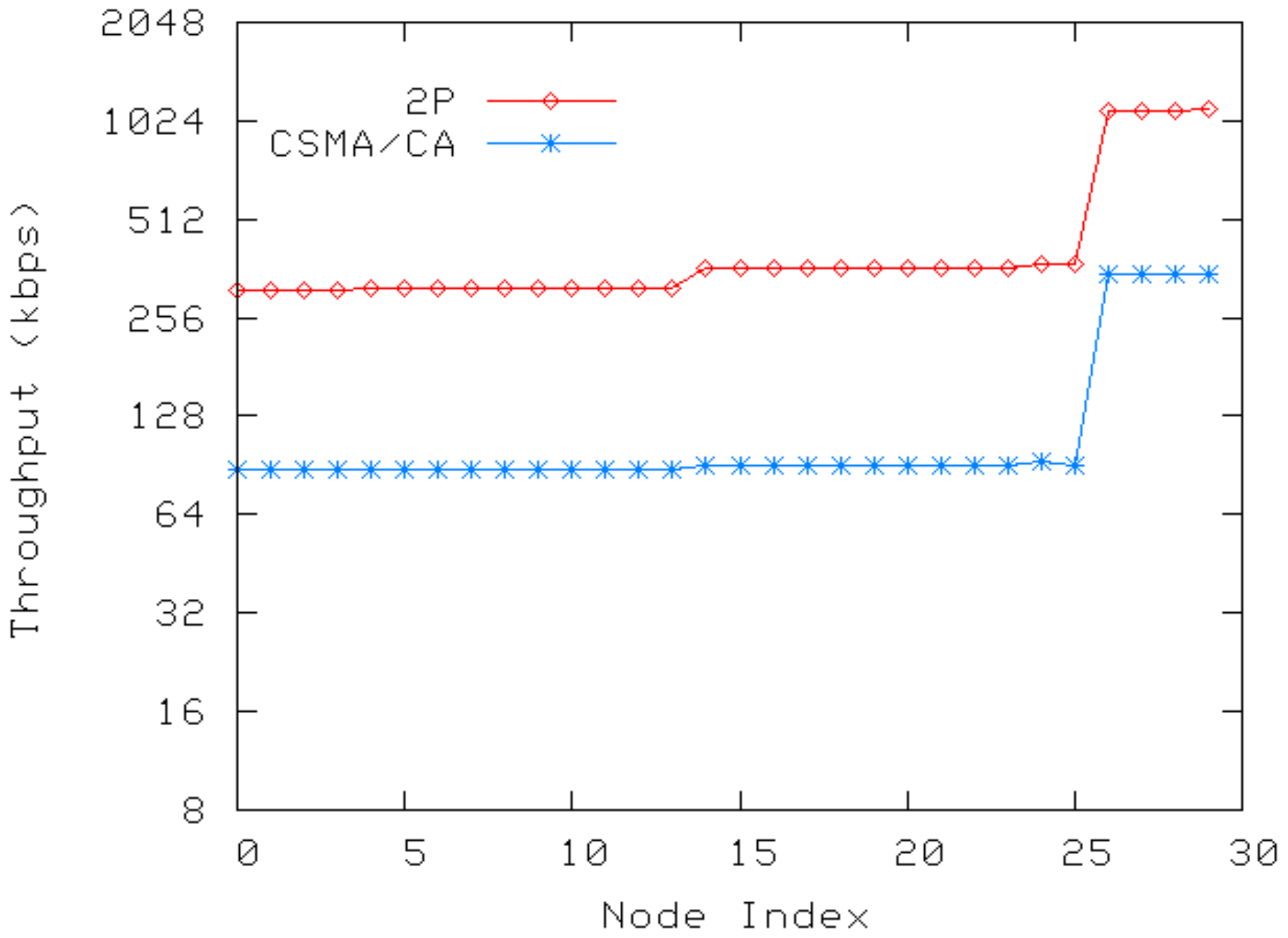
The 2P MAC Protocol

- 2-P: each node switches between SynRx and SynTx
- When a node is in SynRx, its neighbours are in SynTx, and vice versa

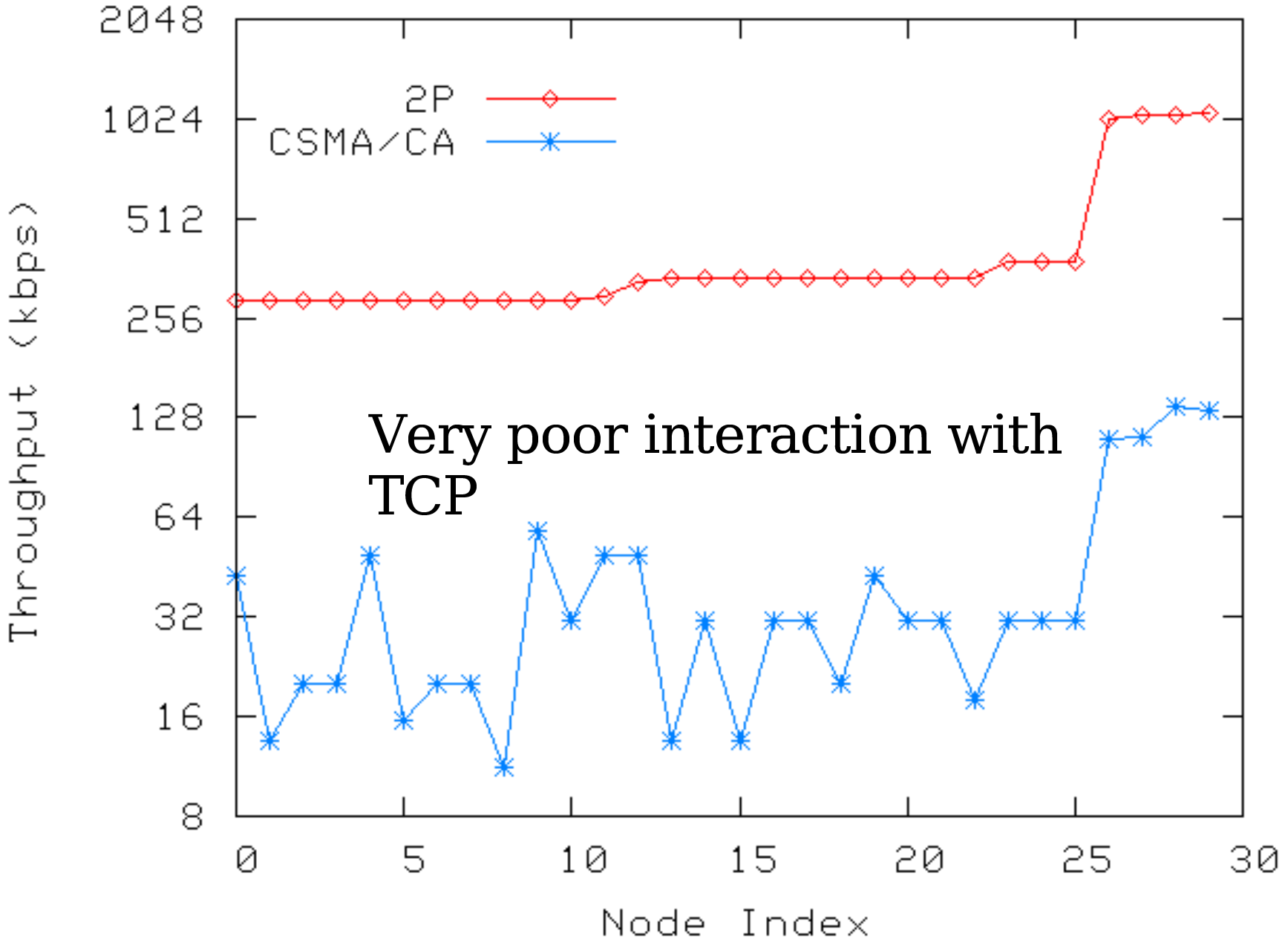


- SynRx + SynTx = 1 *round*
- Require a bipartite topology

2P vs CSMA/CA: UDP

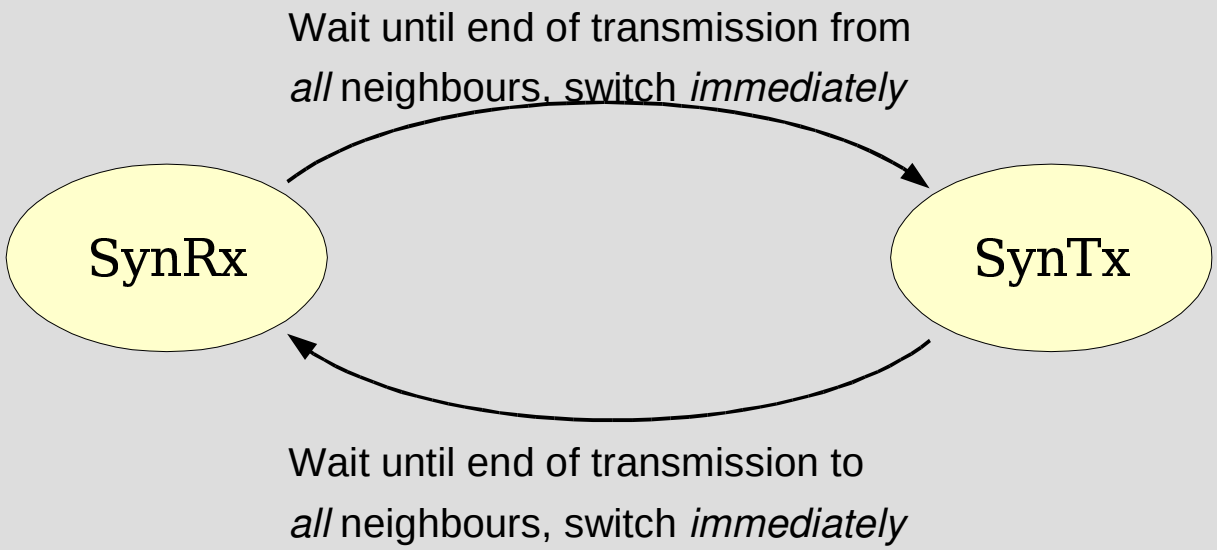


2P vs CSMA/CA: TCP



Some Remarks on 2P

- 2-P can be implemented without tight global synchronization!



- Timeout mechanism to deal with packet losses
- Firmware, proprietary driver software (e.g. Atheros), or driver-level implementation possible
  - Host-AP modifications tested for single-link
- Other issues: topology, TCP performance

Conclusions

- WiFi (802.11) is cost-effective
- But not performance effective
  - Poor spectral efficiency
  - Bad performance in mesh networks
- Performance can be partially fixed
  - Do better scheduling than CSMA/CA
- Further issues:
  - Performance of VoIP, Video
  - 2P extension for a point-to-multipoint scenario