Towards Jamming-Resistant and Competitive Medium Access in the SINR Model

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Andrea Richa (ASU)
Christian Scheideler (U of Paderborn)
Stefan Schmid (TU Berlin/T-Labs)
Jin Zhang (ASU)

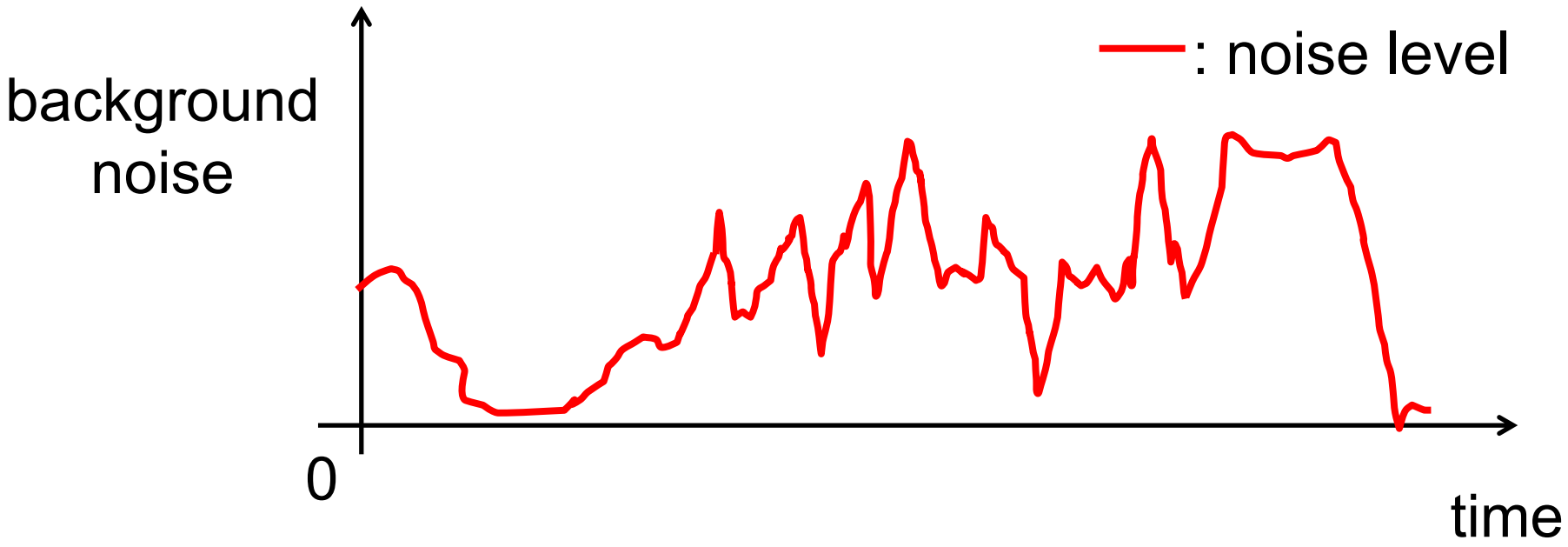
Motivation

Channel availability hard to model:

- Background noise
- Temporary obstacles
- Mobility
- Co-existing networks
- Jammer

Motivation

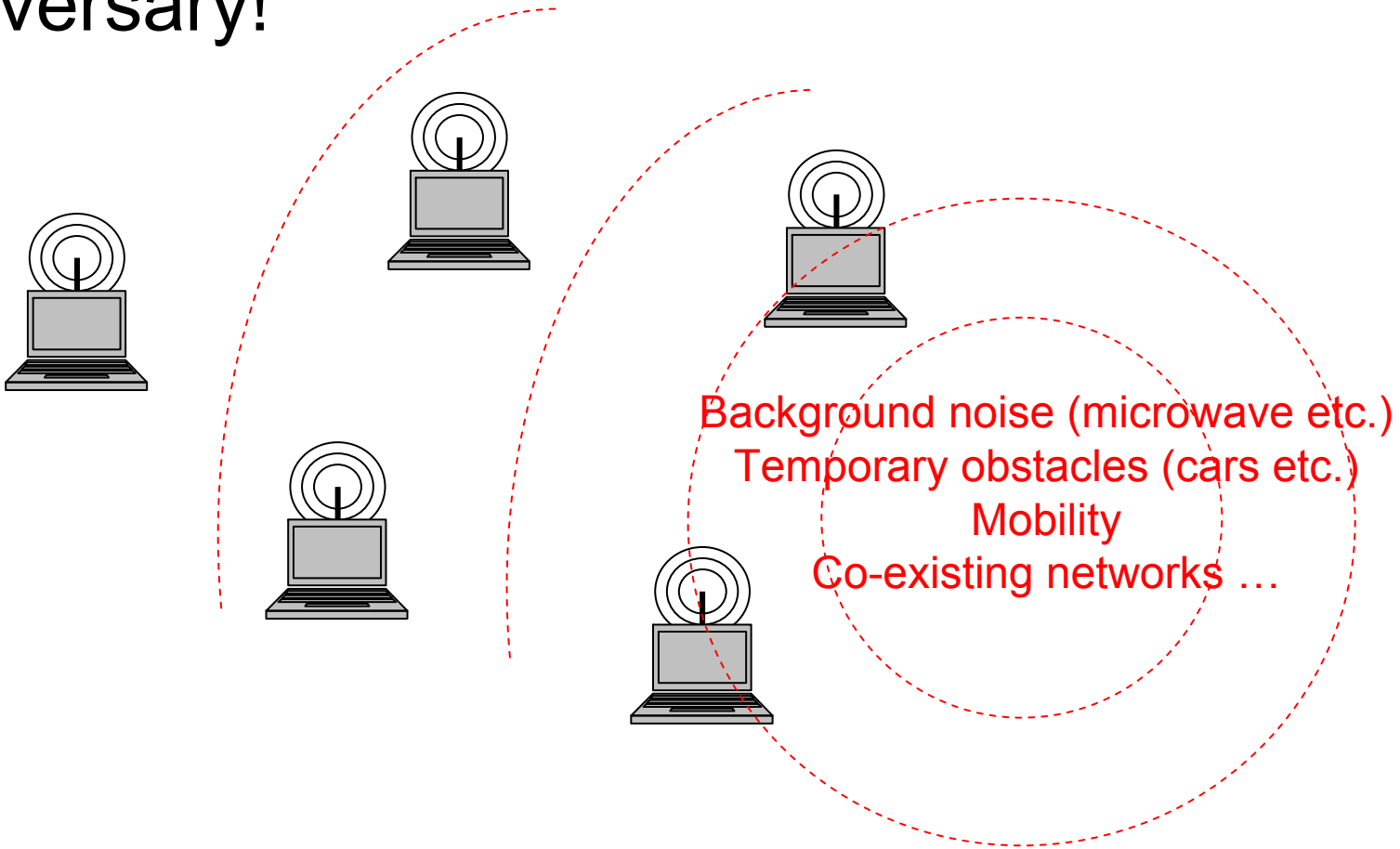
Real world:



How to model this???

Our Approach: Adversarial Jamming

Idea: model unpredictable behaviors via adversary!



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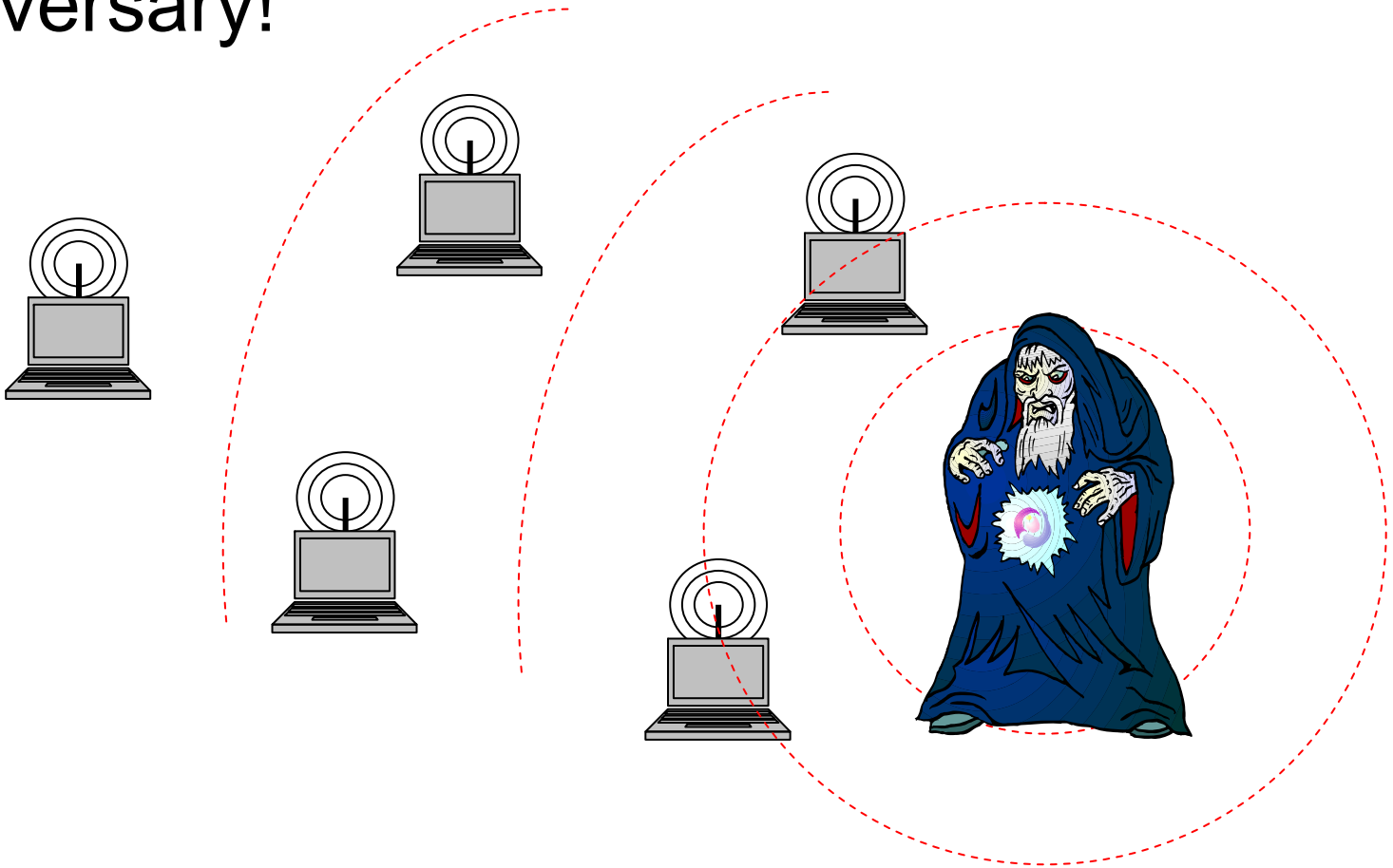
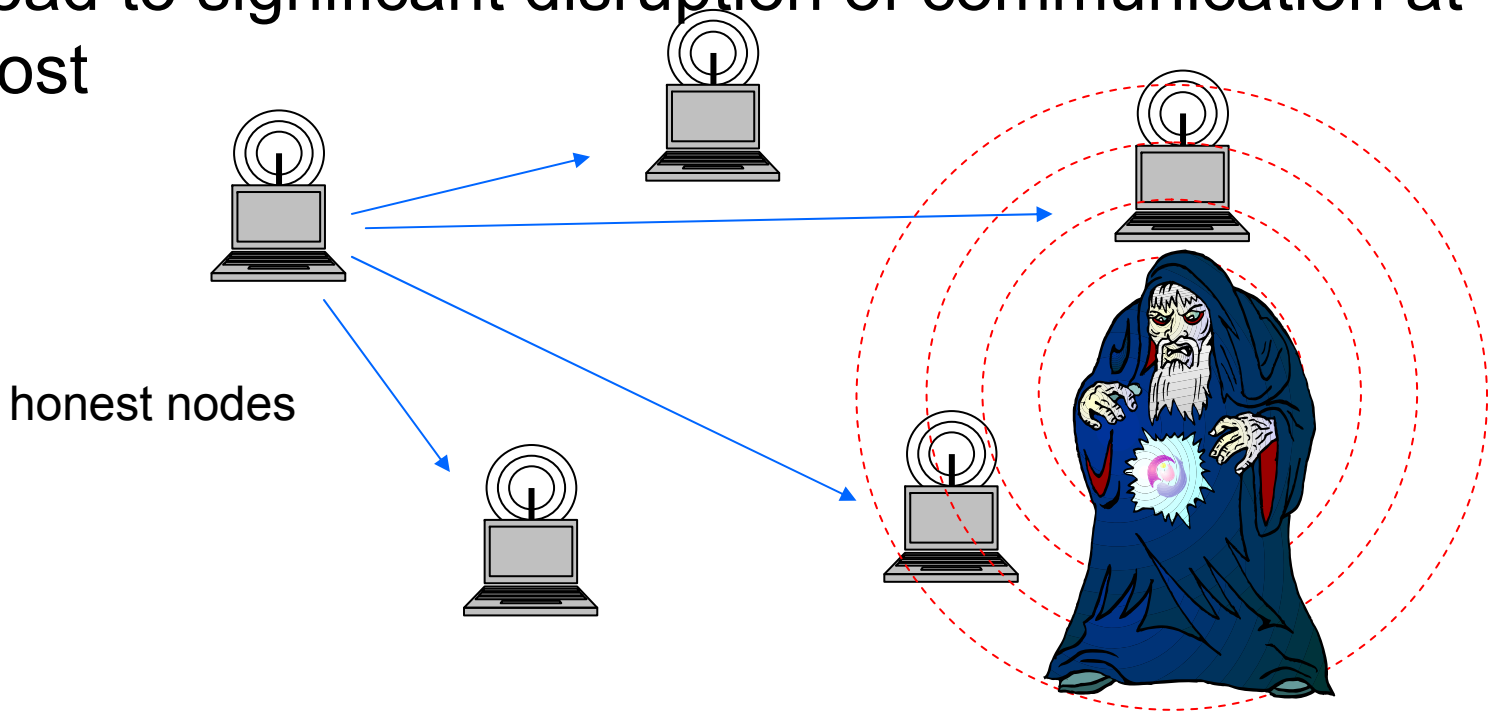


Adversarial physical layer jamming

- an adversary listens to the open medium and broadcasts in the same frequency band as the network
  - no special hardware required
  - can lead to significant disruption of communication at low cost



Adaptive adversary

- Adaptive: knows protocol and entire history
- The adversary is bounded with respect to energy, i.e., it has a certain budget B for each node *v*.
- (B, *T*)-bounded adversary: in any time window of size $w \geq T$, the adversary can add $\leq w * B / T$ to the noise level of each node *v*.

Signal-to-Interference Ratio

$$\frac{P_v(u)}{N + \sum_{w \in S} P_v(w) + J} \geq \beta$$

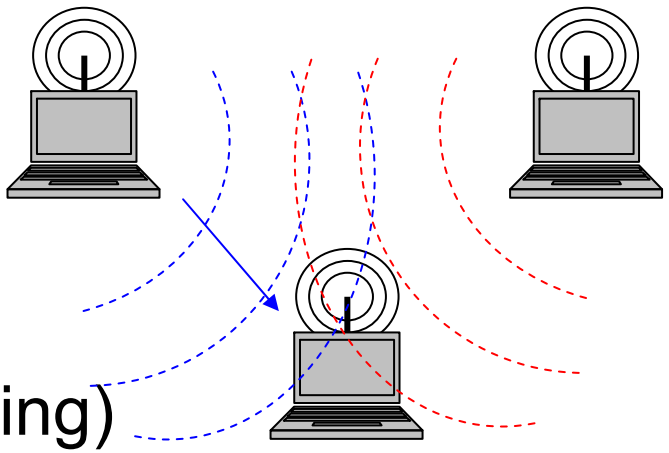
- Move away from any graph model.
- Combined signals from far away nodes can be strong enough to interrupt communications.
- Interference can come from anywhere.

Signal-to-Interference Ratio

- Define N_v as the overall noise level at node *v*.
- No clear distinctions between "idle" and "busy" anymore. A noise threshold τ_v is used by each node *v* to distinguish the two cases.
  - "idle", when $N_v < \tau_v$.
  - "busy", when $N_v > \tau_v$.
- τ_v is adjusted in an adaptive fashion, based on the events observed by node *v*

Wireless communication model

- at each time step, a node may decide to transmit a packet (nodes continuously contend to send packets)
- a node may transmit *or* sense the channel at any time step (half-duplex)
- when sensing the channel a node *v* may
  - sense an "idle" channel
  - receive a packet
  - sense a"busy"channel (cannot distinguish between message collisions and adversarial jamming)



SINR is difficult

- Define *p* as the cumulative transmission probability of all nodes.

- *p* is large, and τ_v is large:
  - idle? busy?

- *p* is small, and τ_v is small:
  - idle? busy?

Hard to tell.

Goal: Maximize the Throughput

- Define ***Throughput*** as the average number of messages successfully received by individual node in the network per round.

SINR-MAC Protocol

- each node v maintains
  - probability value p_v ,
  - noise level threshold τ_v
  - time window threshold T_v
  - counter c_v, and
  - $\gamma = O(1/(\log T + \log\log n))$
- Initially, $T_v = c_v = 1$, $\tau_v = 1$, and $p_v = p_{max}$ (< 1/24).
- synchronized time steps (for ease of explanation)

Basic approach

- a node v adapts p_v based only on steps when an "idle" channel or a successful message transmission are observed, ignoring all other steps (including all the blocked steps when the adversary transmits!)!

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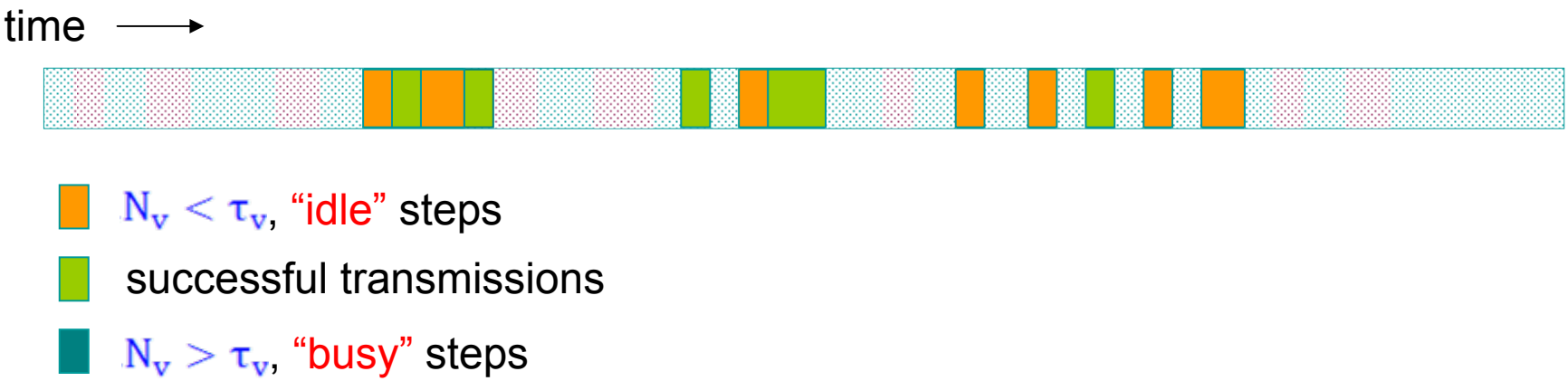
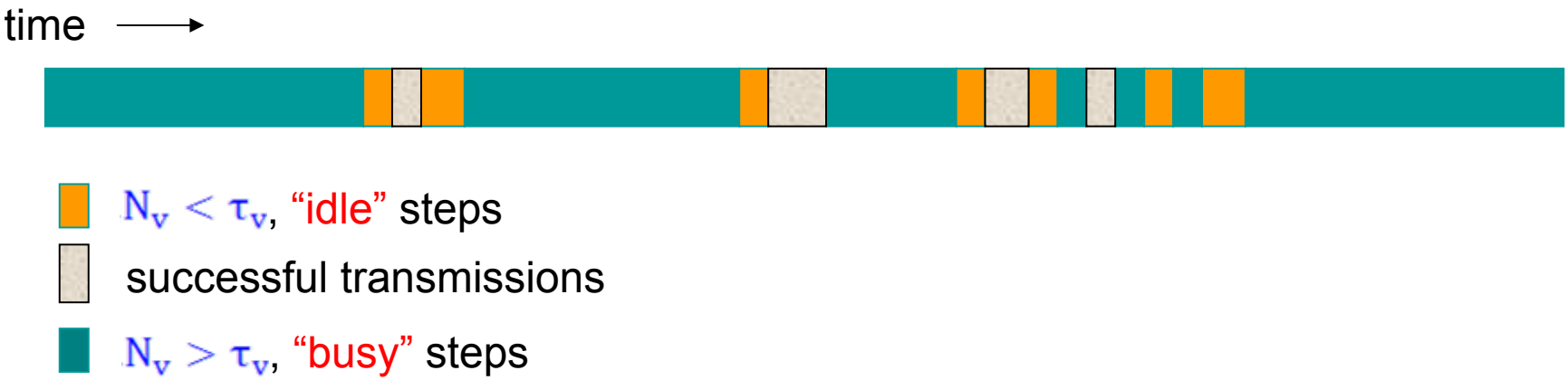


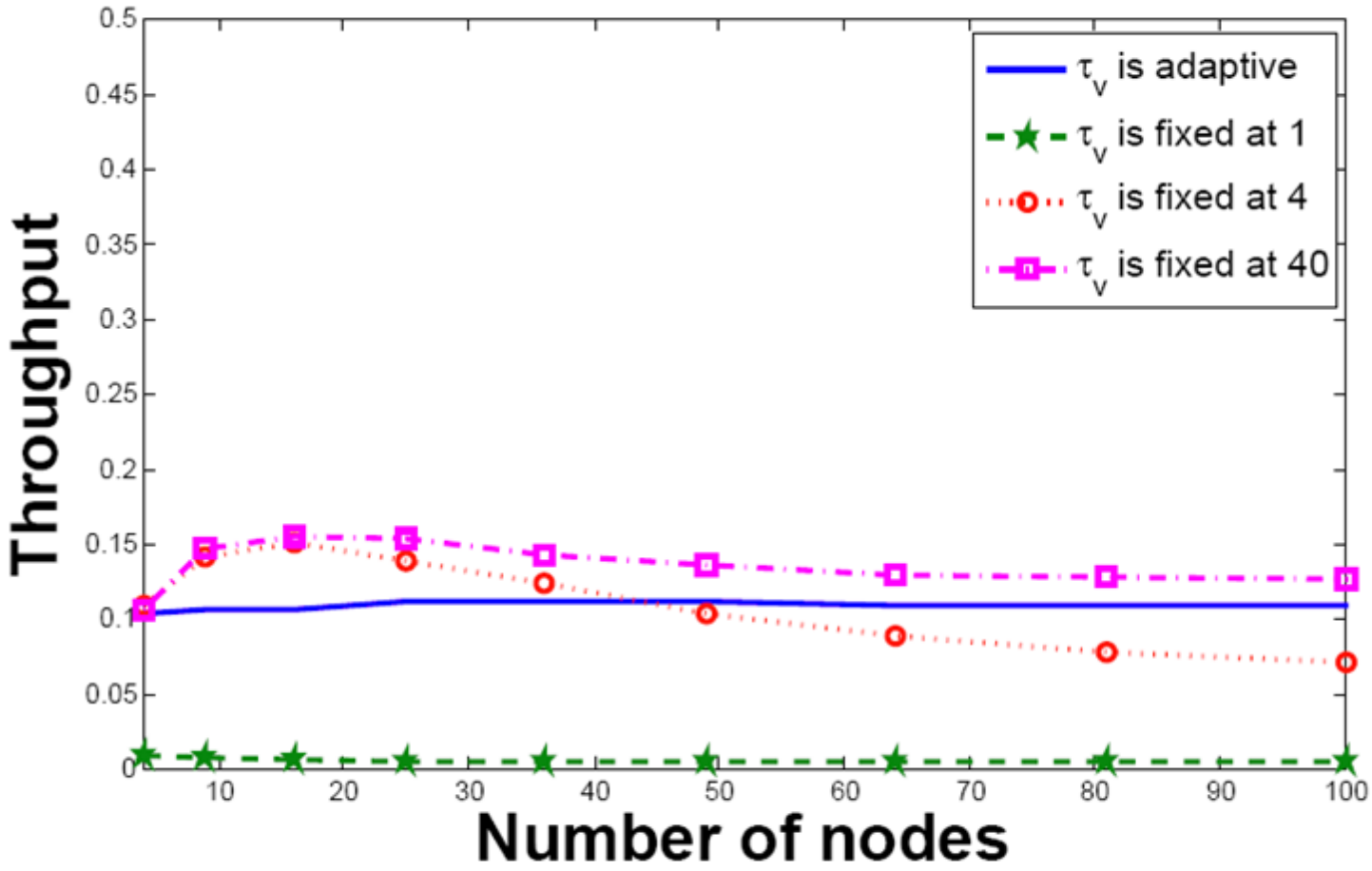
Basic approach

- a node *v* adapts τ_v based only on steps when an "idle" channel or a "busy" channel is observed!
  - τ_v is decreased when channel is "idle" .
  - τ_v is increased when channel is "busy".



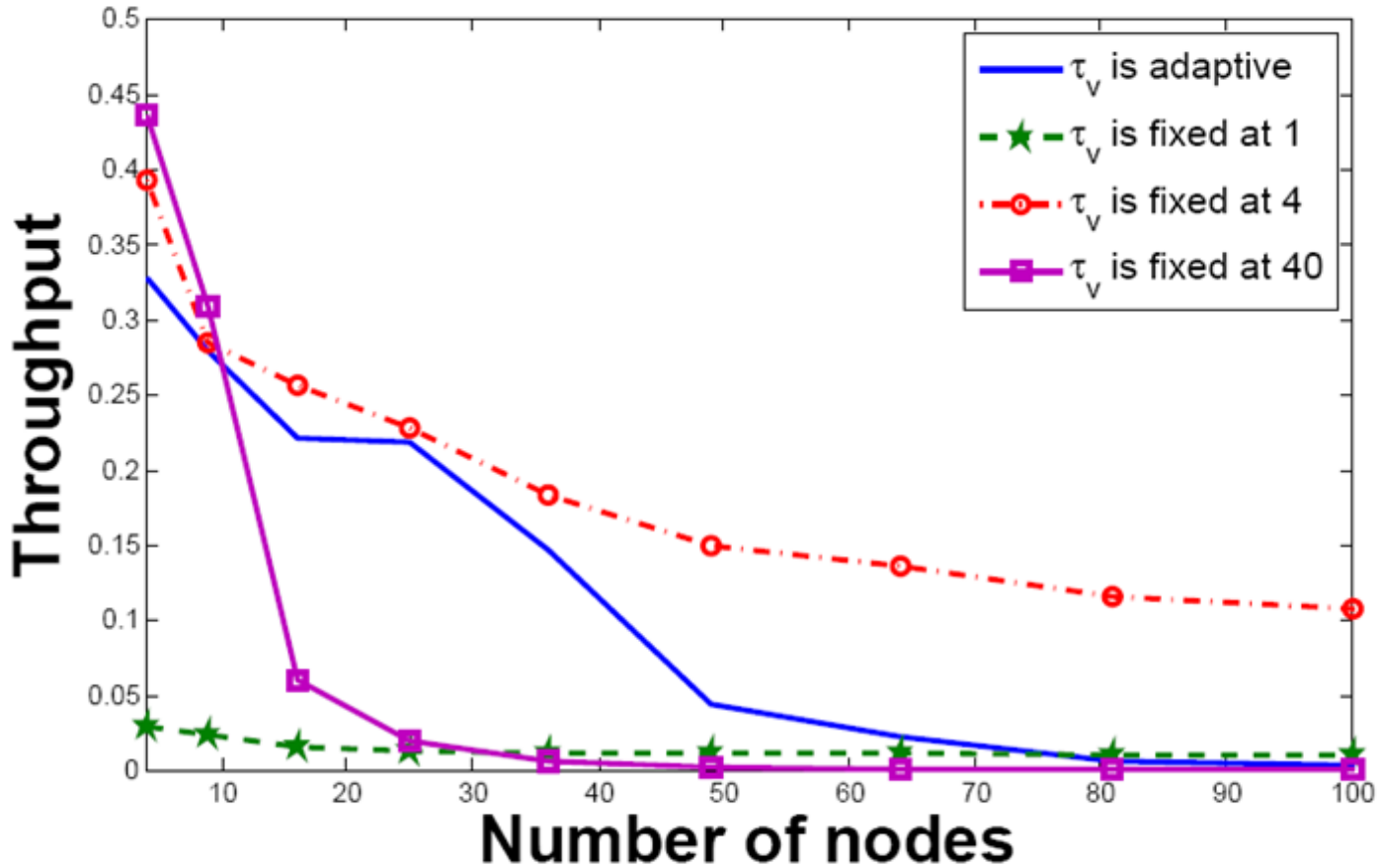
Simulation Result

Experiment 1: Throughput evaluation, p_{max} =1/24.



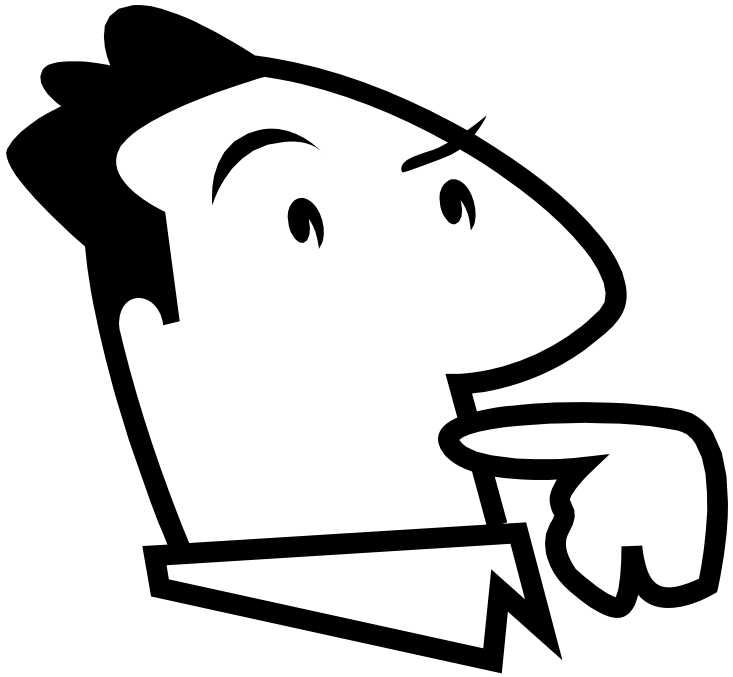
Simulation Result

Experiment 2: Throughput evaluation, p_{max} =1/2.



Related Work

- Our jamming model:
  - Awerbuch, Richa, Scheideler (PODC 2008): MAC protocol for single-hop network
  - Richa, Scheideler, Schmid, Zhang (DISC 2010): multi-hop networks
  - Richa, Scheideler, Schmid, Zhang (ICDCS 2011): reactive jammer
  - Richa, Scheideler, Schmid, Zhang (MOBIHOC 2011): leader election



Questions?