MANETs and Scalability

experiences from the funkfeuer.at network
Vienna, 2004-2005

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Scalability - variants

- Scalability of mesh routing protocols: big discussion in literature (> 8000 papers in ACM)
- scalability on the WLAN bandwidth side: bad!
- scalability on the social side - IP spaces

Scalability of mesh routing protocols

- don't scale up so well in simulators with 1000nds of nodes. We are not there yet
- promising new solutions like HLSL (http://en.wikipedia.org/wiki/Ad_hoc_protocol_list)
- wardrop routing - optimum (http://decision.csl.uiuc.edu/~wireless/wardrop/)
- We will arrive there - but not so urgent. OLSR is fine for now.

Problems of WLAN

- Well known O(1/n) or even O(1/2^n) scalability: A sends to B and B should re-transmit on the same channel => A can not send during this time frame.
- Exact O() function in practice not known - disputed.
- Worst case scenario: 10 people per hop. 4 hops omni-omni connections => at the end only 1/16000 of bandwidth! (”Ugly truth about mesh networks”)

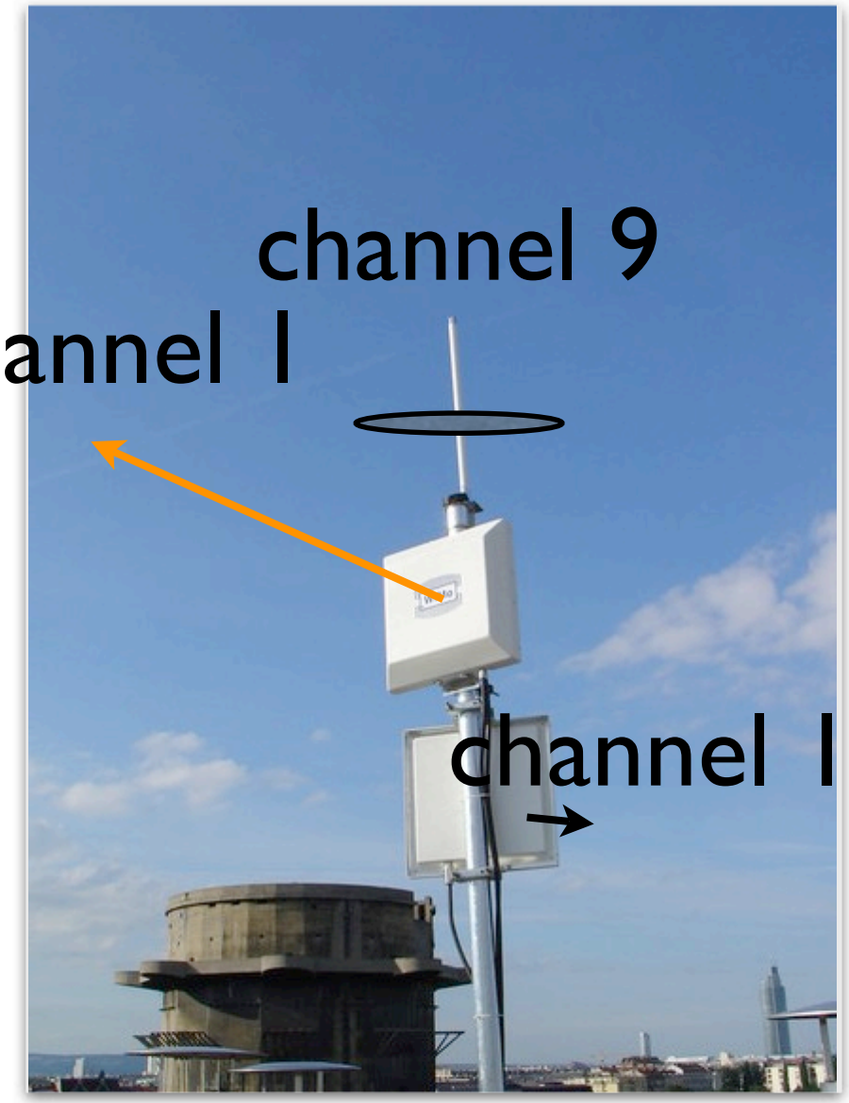
What went wrong?

- MANETs: idea of ad-hoc mode, same channel was practical for testing in the lab

- Effect in real community networks or bigger: we are stepping on our own feet. Self-interference!

First approach by funkfeuer

- Everybody **must** install one omni and one or two directionals
- Directionals on their own channels, WEP protecting against joining the directional-to-directional link by accident. Omni is open for all.

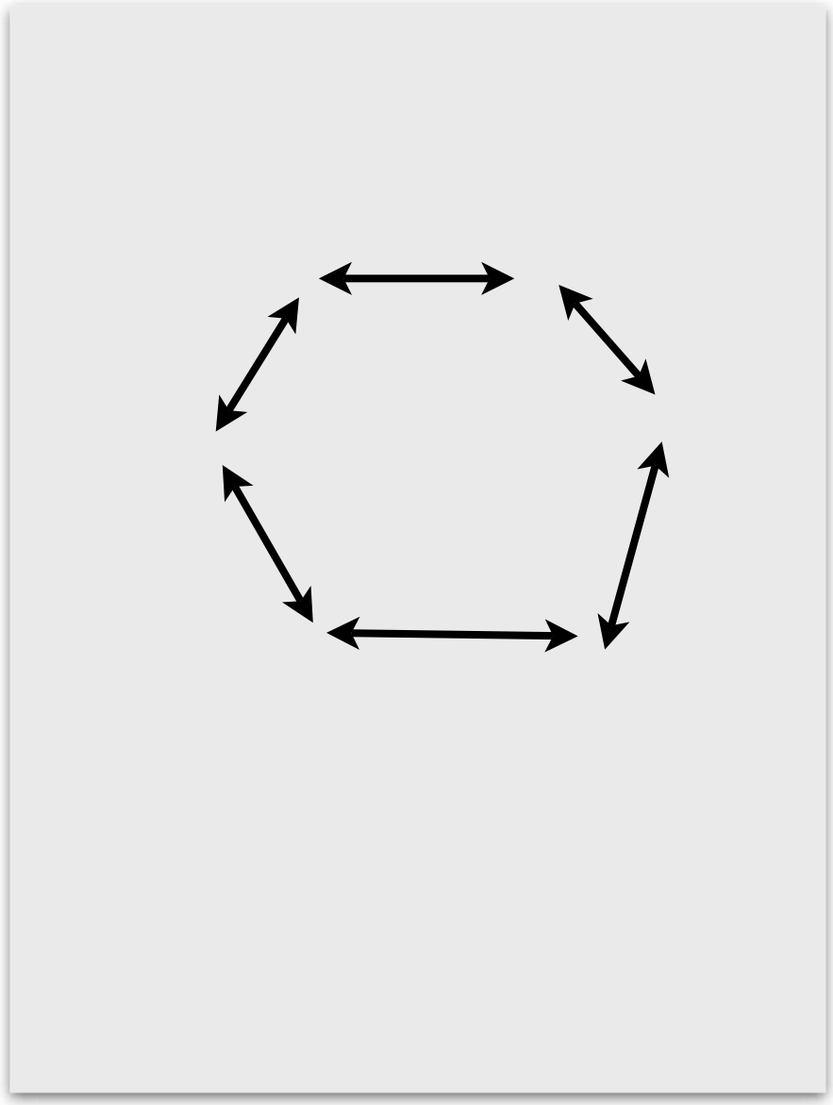


What can we do with that?

- topology wise: the directionals antennas can already form a ring.

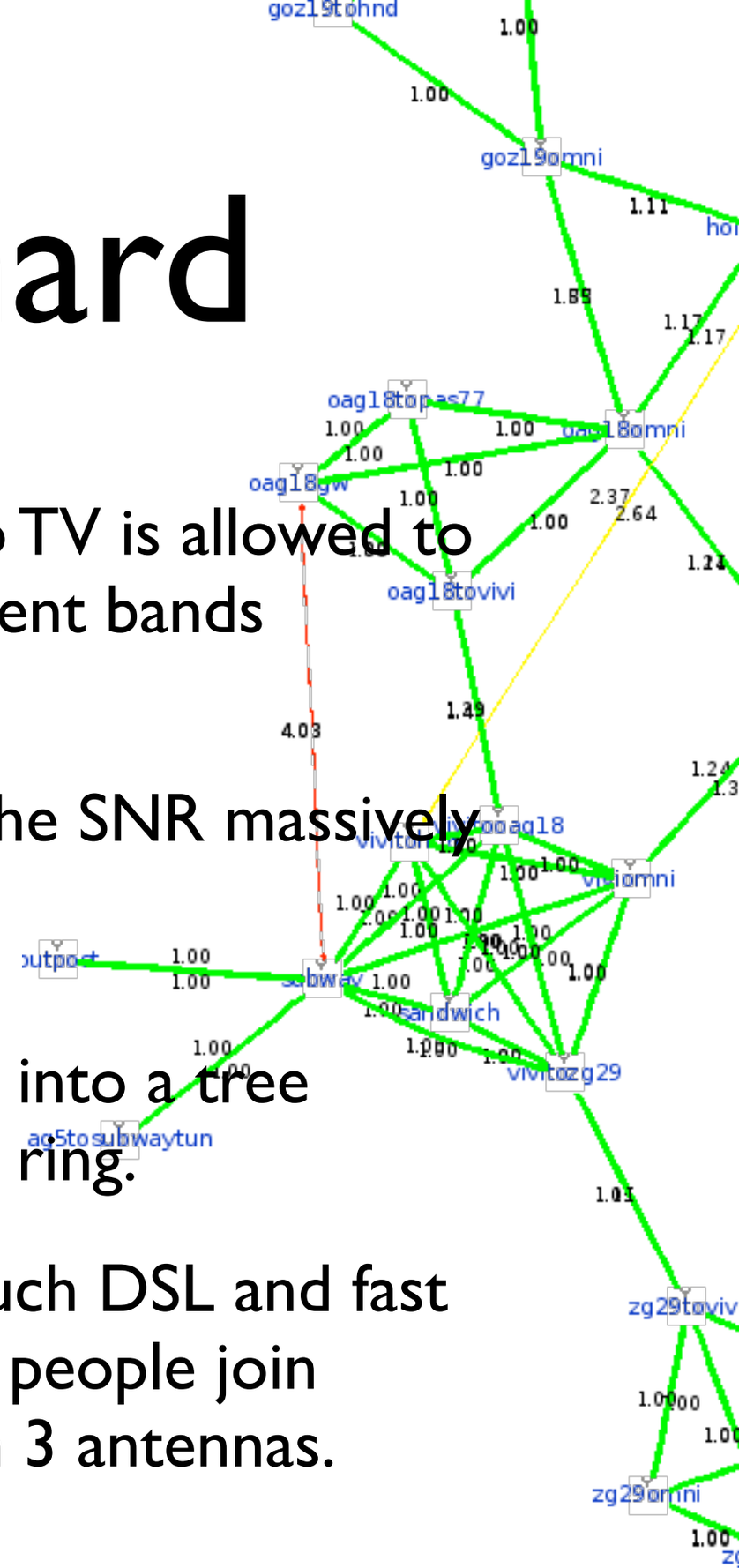
- A can send to B (half-duplex!) and B can re-transmit to C at the same time.

- Add some omnis and you are fine



Reality bites hard

- But: channel 5-9 was taken! amateur radio TV is allowed to send with > 40 Watts. No three independent bands available.
- Many normal WLANs in buildings lower the SNR massively
- microwave ovens
- No ring! It just happened that it collapsed into a tree because not everybody could join a single ring.
- Finally: users here are lazy! We have to much DSL and fast connections. Only freaks/really interested people join funkfeuer. And only they spend money on 3 antennas.

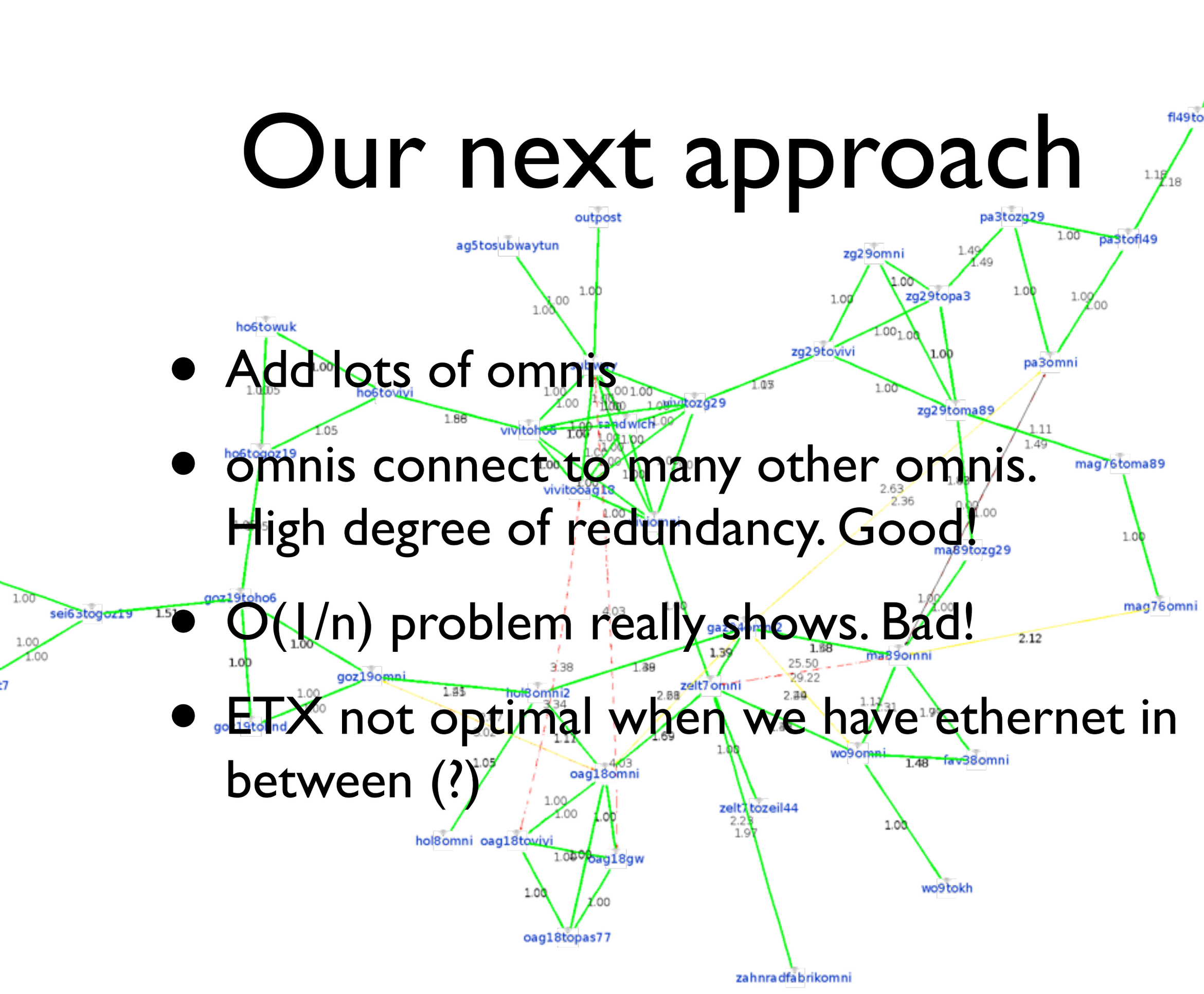


Reality bites hard(2)

- People expect switch-style behaviour, e.g.: Add a full duplex cable (node) and it will behave like a n-to-m full duplex switch/ router. No bandwidth loss, small latency, high uptime, no maintainance. One power button and it is connected.
- People have a normal day time job as well

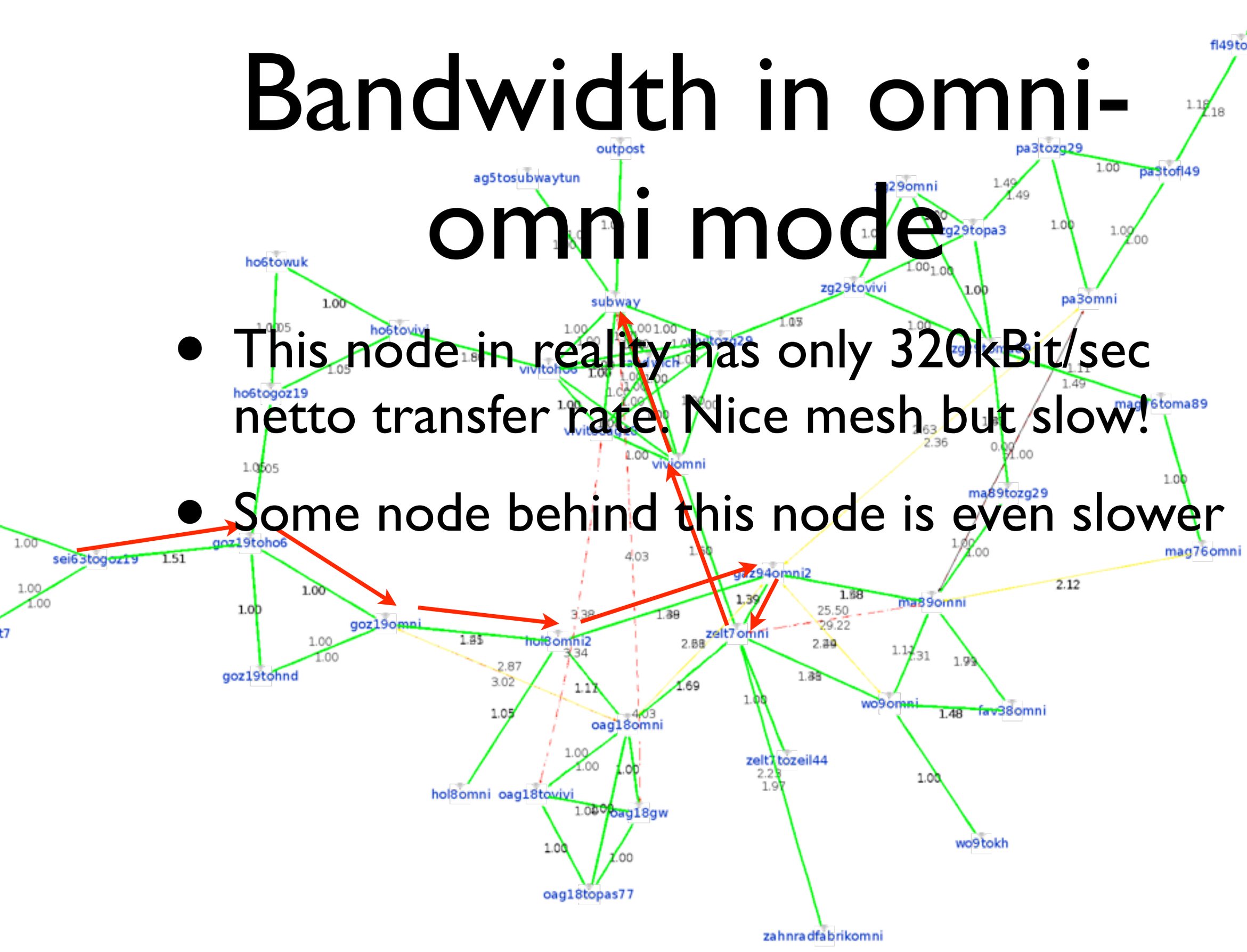
Our next approach

- Add lots of omnis
- omnis connect to many other omnis. High degree of redundancy. Good!
- O(1/n) problem really shows. Bad!
- ETX not optimal when we have ethernet in between (?)



Bandwidth in omni-omni mode

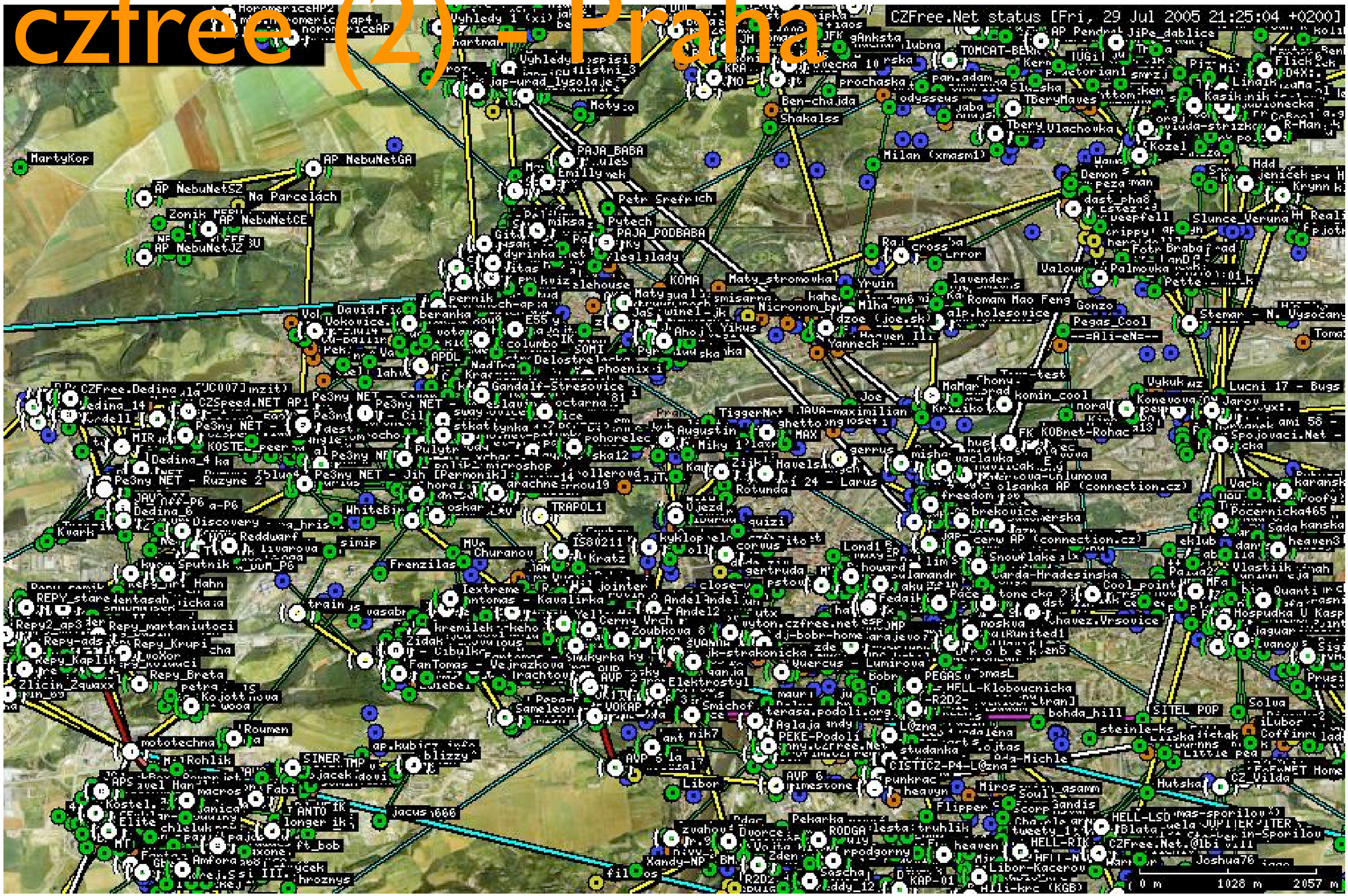
- This node in reality has only 320kBit/sec netto transfer rate. Nice mesh but slow!
- Some node behind this node is even slower



A different example - czfree.cz

- The czech community built a network of around 10000 users in just 3 years. How?
- stay local, act local, join to each other via leased lines. Share the costs. Use any tech that you can. Make it cheaper than ISPs.
- There was **no** normal cheap DSL 3 years ago in the czech republic
- Ronja! Free scale optics (FSO) optical links: 10 mbit symmetric for approx. 1 km distance.

czfree (2) - Praha



czfree(3)

- In use: OSPF within clouds, BGP between clouds
- full duplex Ronja
- too many users! leased lines expensive for operators
- almost like many small commercial ISPs

Ronja

- we are currently working on one
- mechanical setup complicated
- problem: haze, fog, heavy rain
- not mass produced (yet)

Why not czfree approach?

- We want mesh!
- We want to be mobile
- We want scalability AND mesh
- We want sensor networks
- We want that everybody can set up a mesh node without becoming ISP for his neighborhood.
- OSPF is good for cabled nets, not for changing networks
- We want the cake AND we want to eat it too.

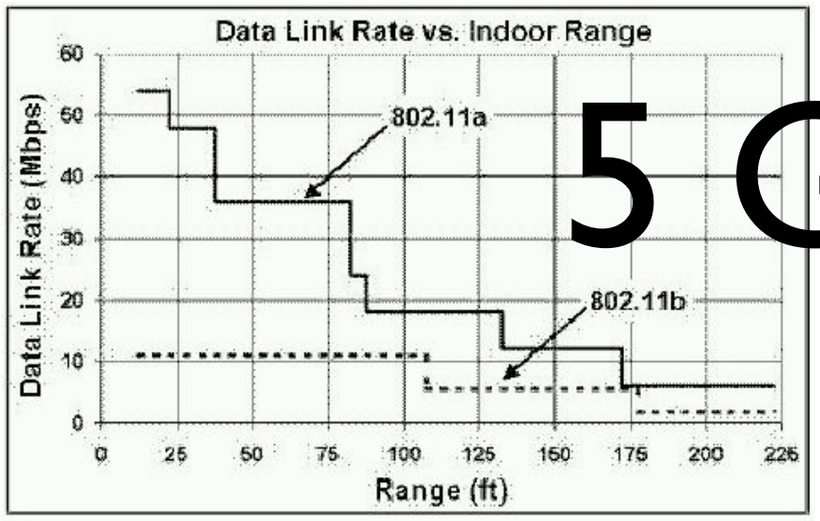
Next steps for funkfeuer

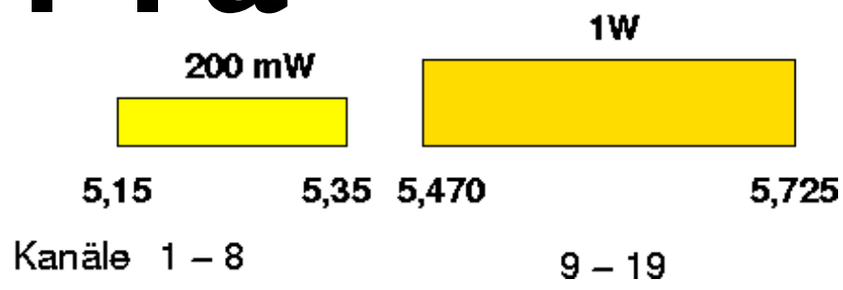
- We need better layer 2 tools/equipment!
- Linksys are nice but we will design our own stuff
- Research and test on 5GHz meshboxes
- The following slides will only concentrate on “why” and “how”

Enter >= 8 channels

- Remeber: we want switch style behaviour! full duplex, no packet loss, small latency
- Next attempt: 5 GHz has min. 8 independant channels. combine 2 for full duplex
- Add one omni 802.11b/g omni for on the street access (compatability)

5 GHz, 802.11a





- 5GHz advantages: more independent channels, same datarate, not overcrowded
- smaller reachability BUT higher gain allowed (1Watt). Estimate: 2/3 of range of 802.11b - that's fine as long as we have more channels
- Well supported by Atheros chipsets
- Let's give it a try!

Ingredient #2

- Automatic Power back off
- On each node and each wifi card:

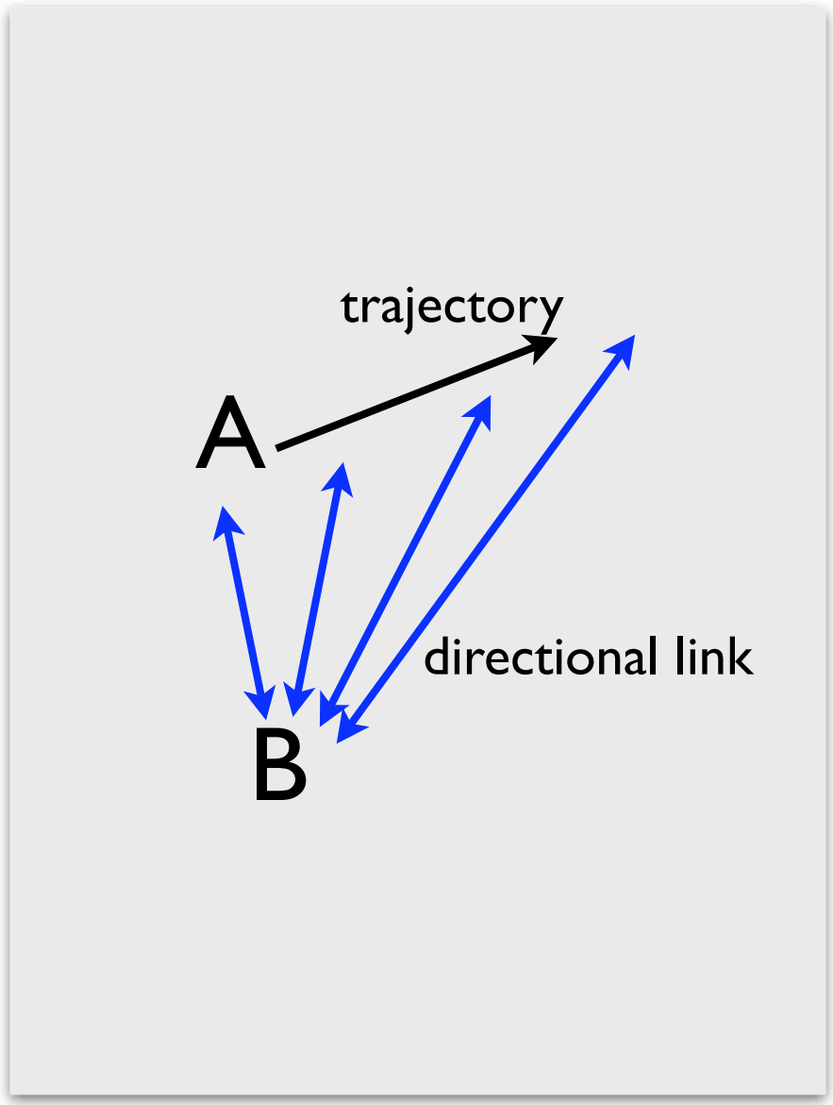
```
while (1) {
    if can_see > 4 nodes
      reduce power
    else if can_see < 2 nodes
      increase power
end while
```

Automatic Power back off (2)

- Idea: stay connected to at least k nodes BUT use as little power as neccessary while keeping maximum bandwidth / SNR
- Try not to “spam” your signal to far away

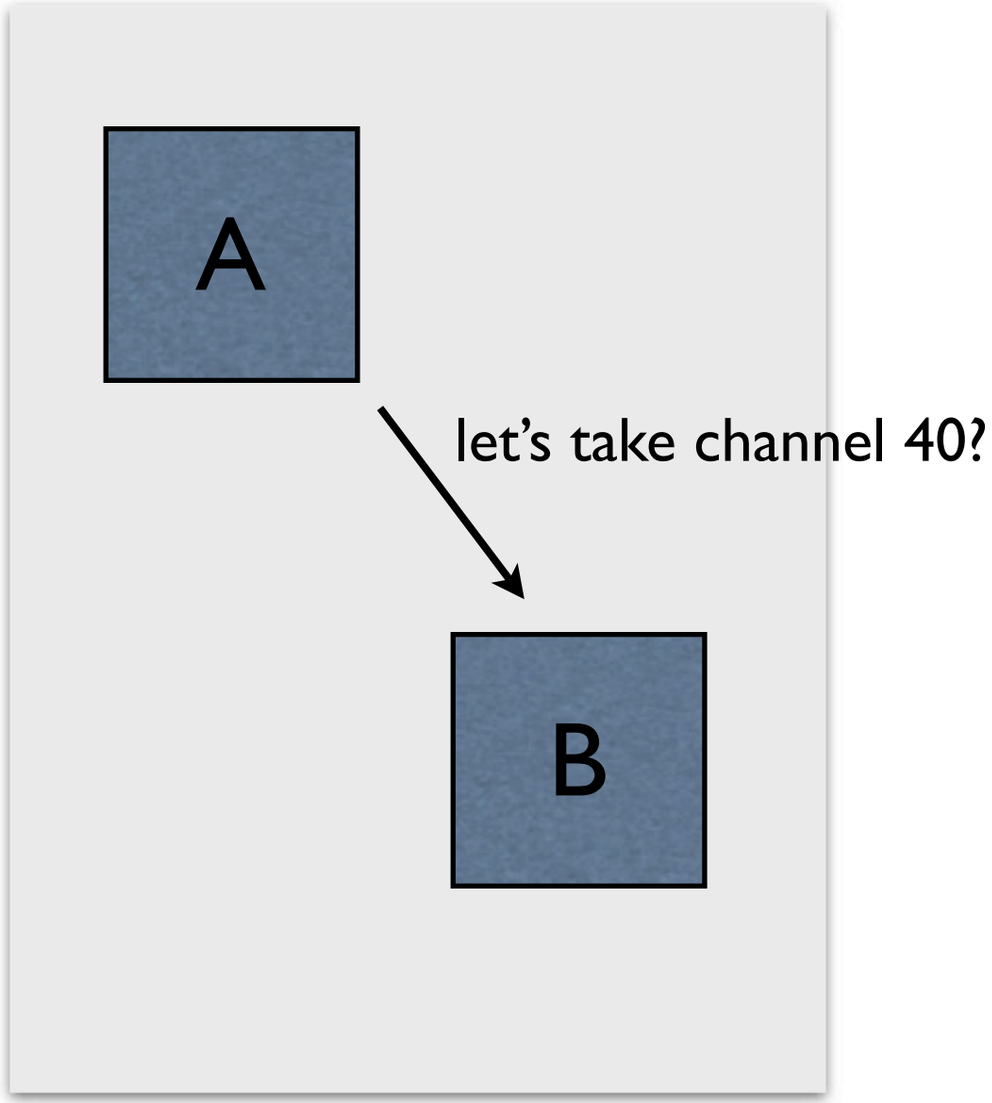
Ingredient #3

- MIMO / Antenna diversity
- directional links "with a motor" (via interference patterns)
- Node A moves around, B will adjust its MIMO beam to follow
- BUT: need more antennas! Still seems to be expensive
- BIG Advantage: reduces self interference



Ingredient #4

- auto channel selection
- distributed agreement protocol: take the channel which is the furthest from all others AND which has optimal SNR
- Can be realized as OLSR plugin



How does it look like?

- many antennas :(
- built in 4 or 8 x 802.11a cards, 1x 802.11b/g
- Doable? Price? 400-500 euros. To expensive?
- Better ideas?

future: local optimization for global problems?

- Each node has all the topology in OLSR
  => can decide locally how things would change if the node decided to join another directional link
- Many unanswered questions: will the graph still be connected? Will it increase bandwidth? Better ETX?
- Interesting idea, but some theoretical CS work has to be done on this first