MANETs and Scalability

experiences from the funkfeuer.at network
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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 too 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(I/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
• 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 \( \geq 8 \) channels

- Remember: 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 (1 Watt). 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 necessary 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

let's take channel 40?
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. Too 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