Structure and Evolution of a Large-Scale Wireless Community Network

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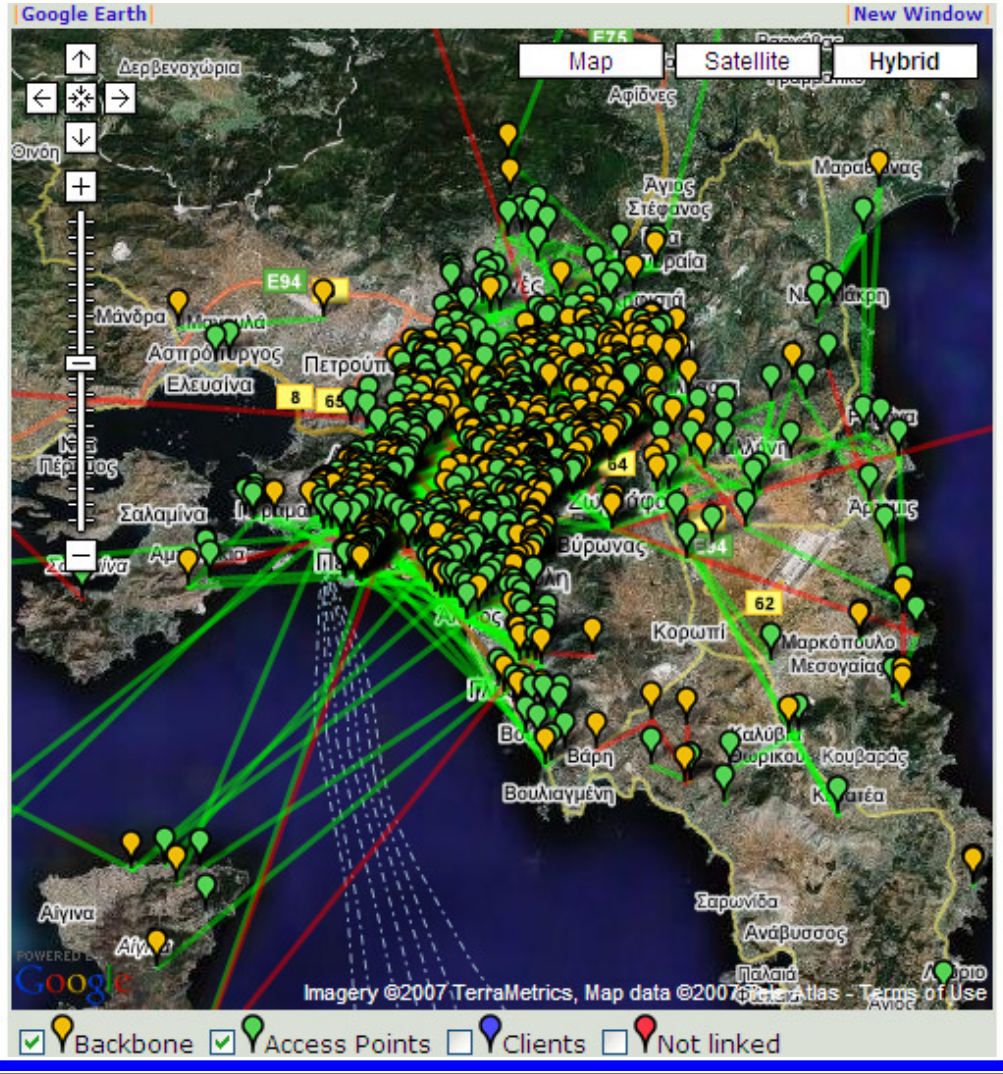
Wireless Nets in Metropolitan Areas…

- “Ubiquitous” Wi-Fi coverage in metropolitan areas
- Infrastructures based on Wi-Fi for public Internet access
- Wireless Community Networks
  - wireless mesh networks
  - organized by radio enthusiasts
  - cover metropolitan areas
  - numerous WCNs around the world
  - Athens Wireless Metropolitan Network
    - one of the largest

Athens Wireless Metropolitan Network

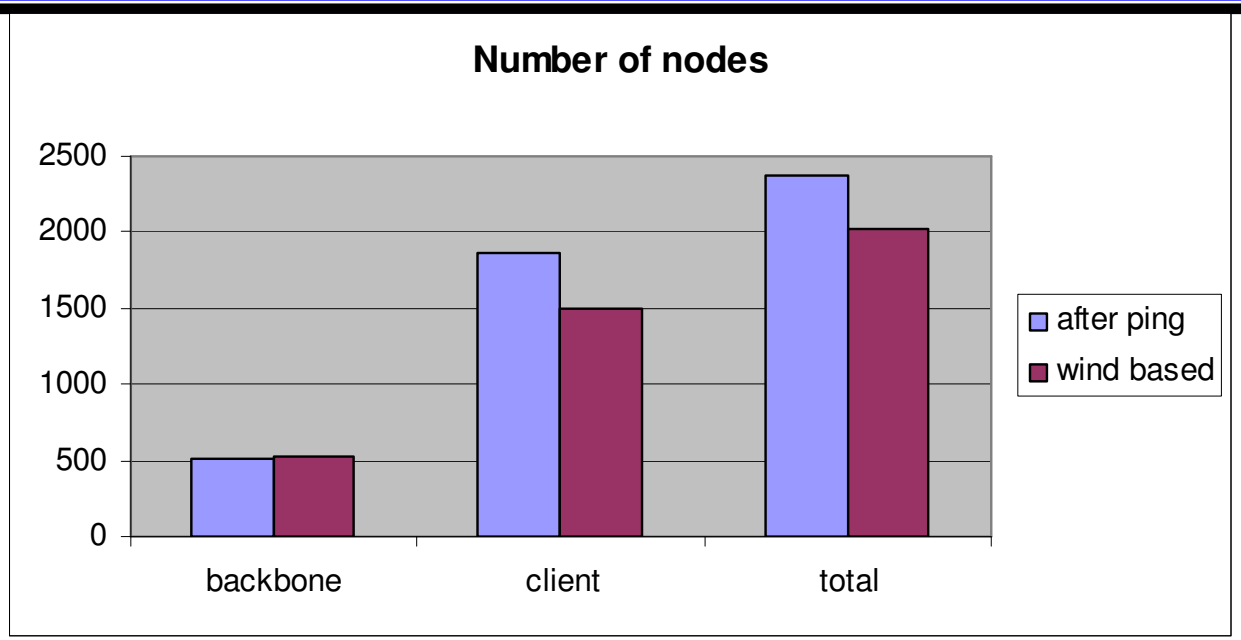


- **among the largest, globally**
  - **2010 active nodes**
  - **2354 links**
  - **655 active services**
- **Node #66 @ MMlab**

Investigation

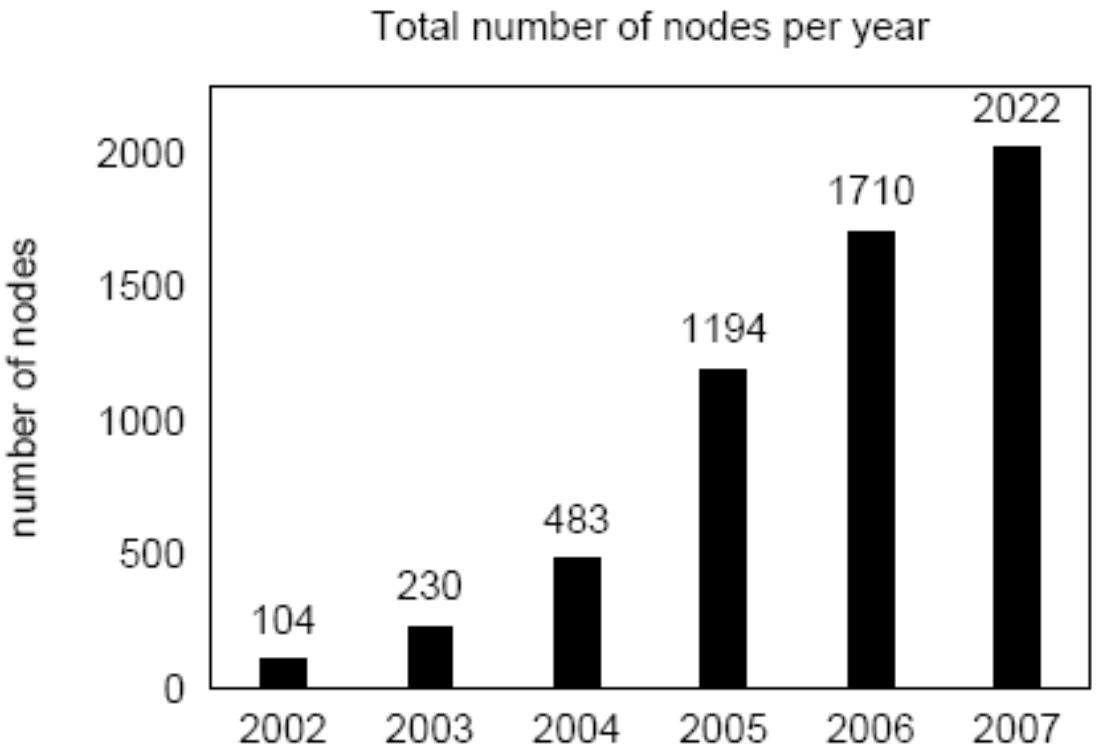
- Our results come from
  - Information stored in WiND database
    - Wireless Node Database
    - available on the Internet
    - stores data about nodes, links, services
  - Measurements that we made from our AWMN node (aueb|mmlab, #66)
    - measurements were repeated on 5 different days and at different times
- We investigate divergences between the two sources

Number of Nodes in AWMN



- Many client nodes connect temporarily and are not always registered in the WiND database
- Backbone nodes are always registered and more stable
- Total number of nodes
  - 2369 according to our measurements
  - 2022 according to WiND

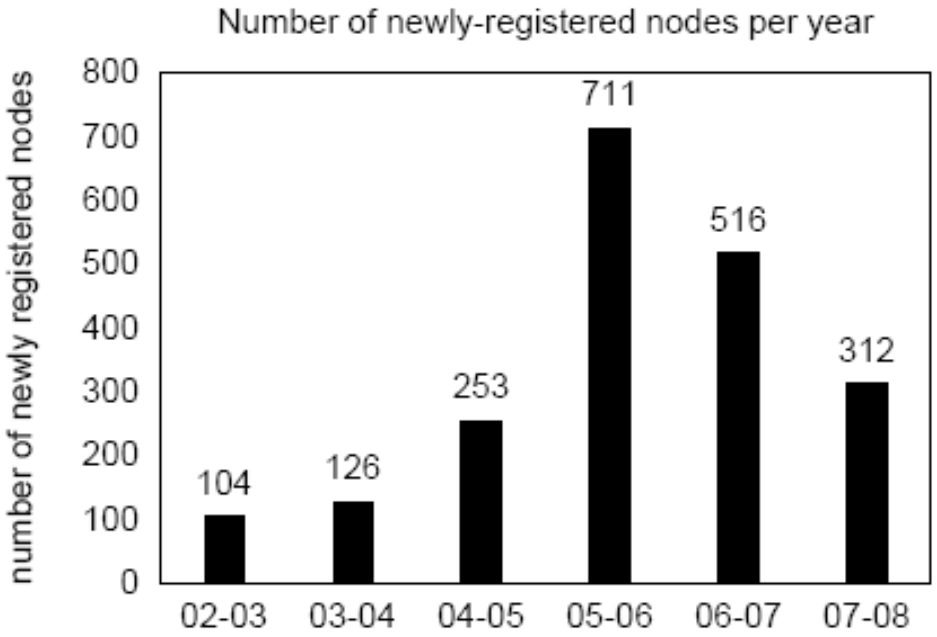
Evolution during the years

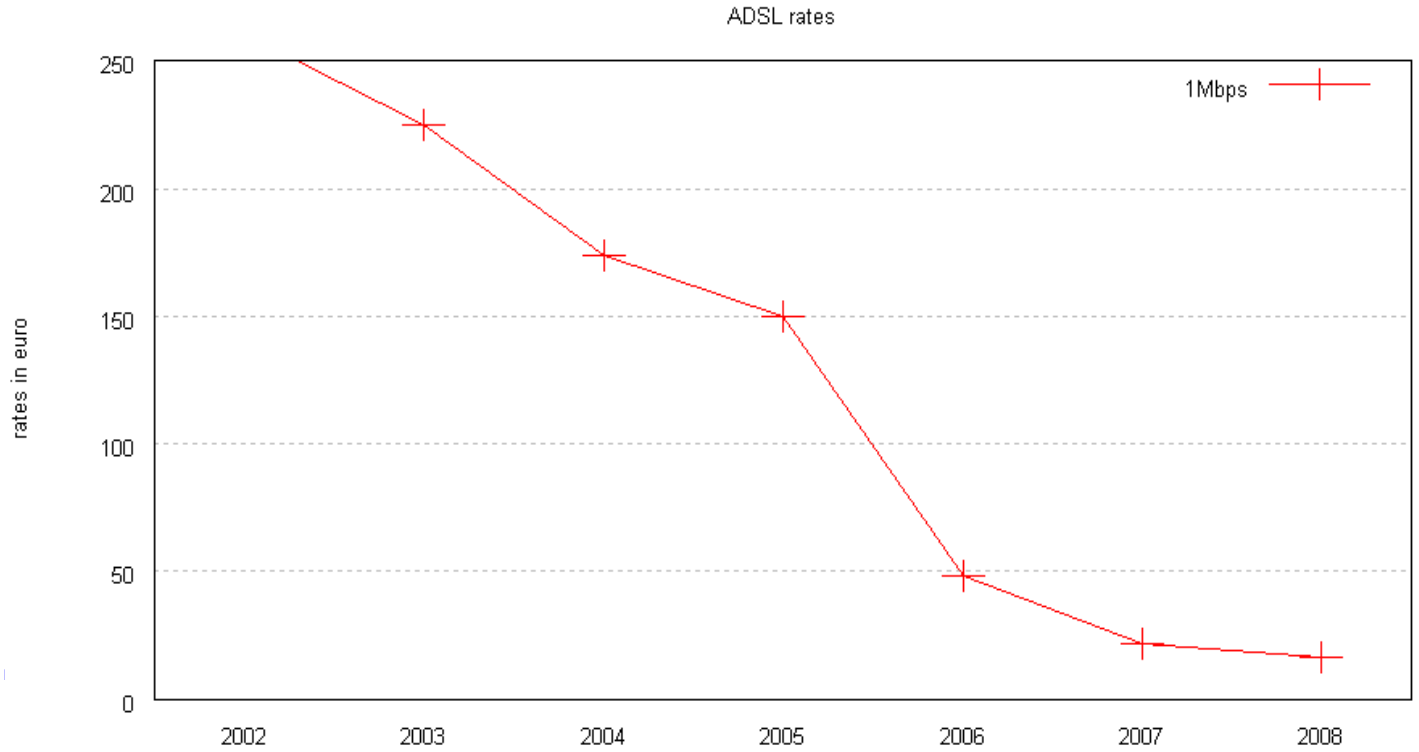


- The size of AWMN has always been increasing

Number of newly registered nodes per year

- They started decreasing after 2006
- ADSL price decreased significantly during the same period

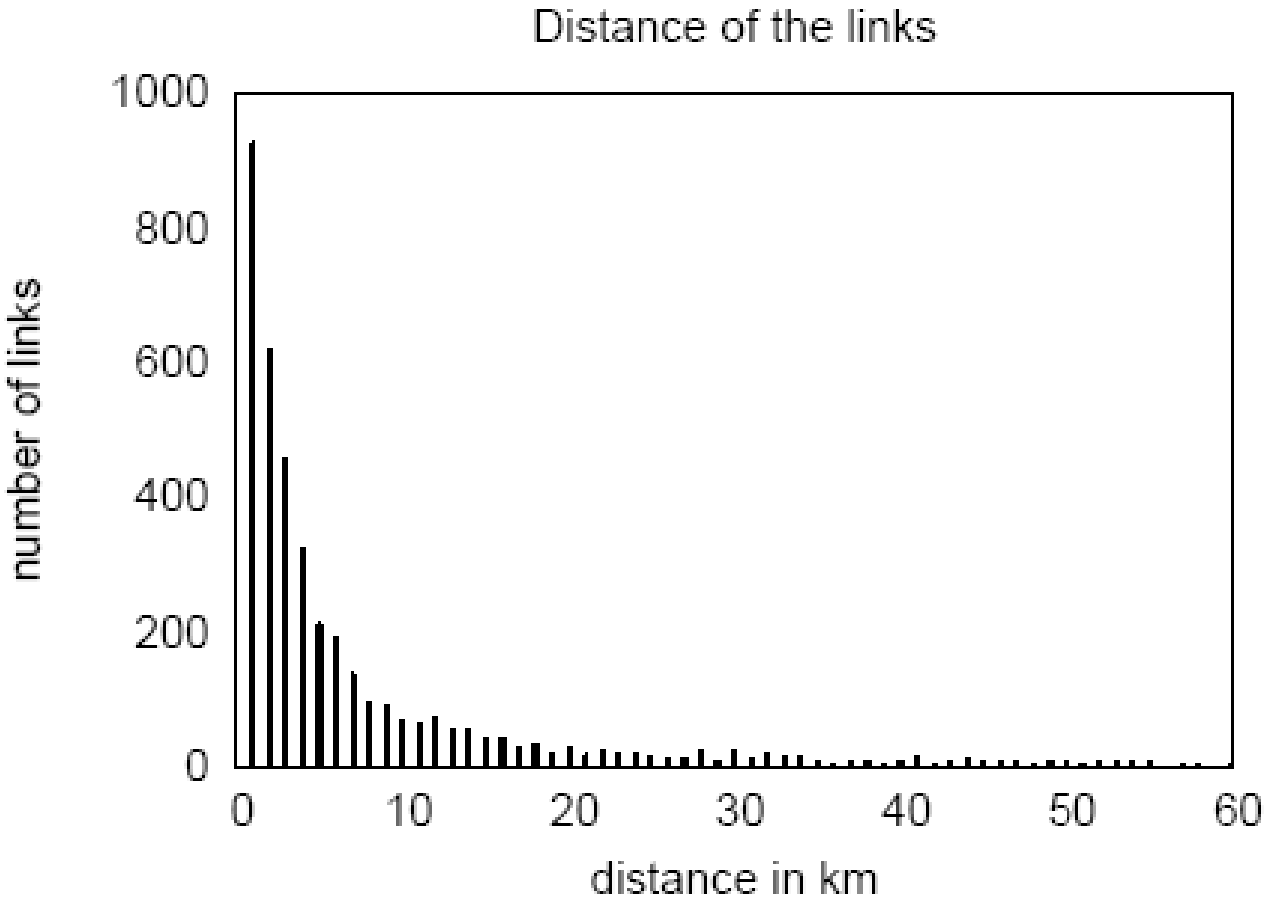




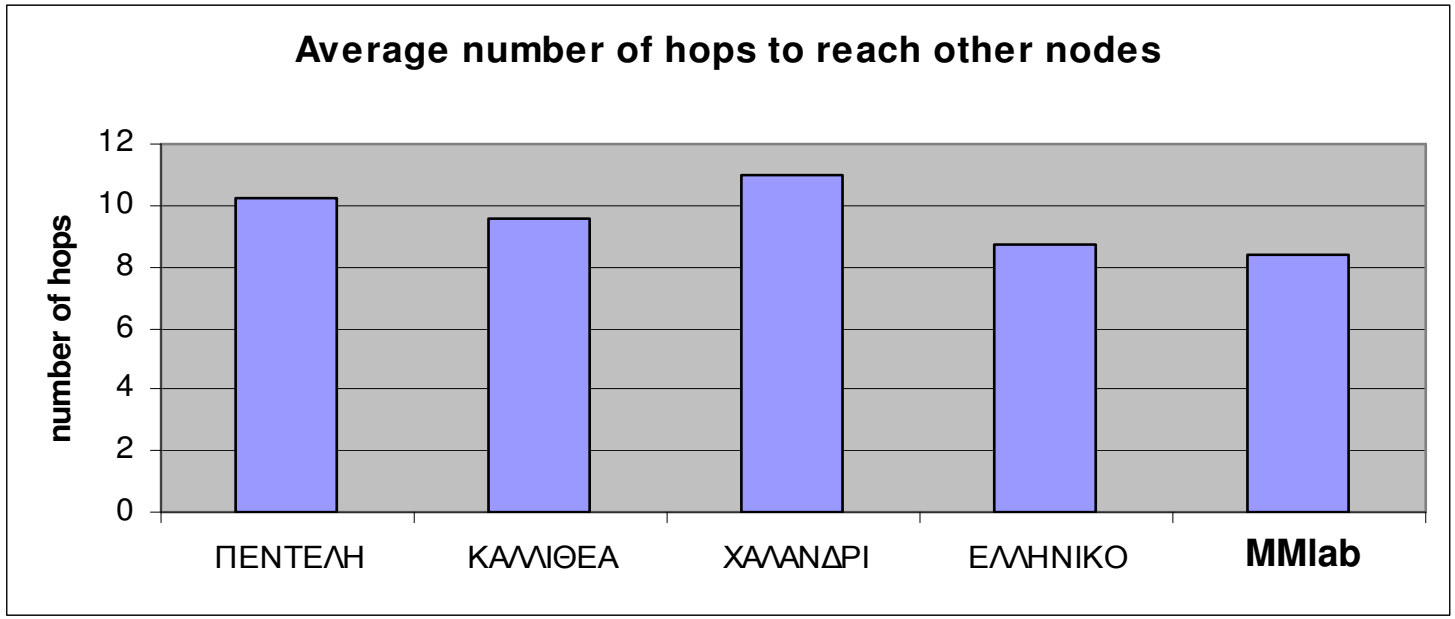
- Expensive broadband connections were one of the major factors that encouraged the creation of AWMN

Distances of the Links

- Most links have distance of about 1km
- Shortest link 8m
- Longest link 124km (!)
- Power is within bounds (20dBm)
- Some links extend to neighboring cities

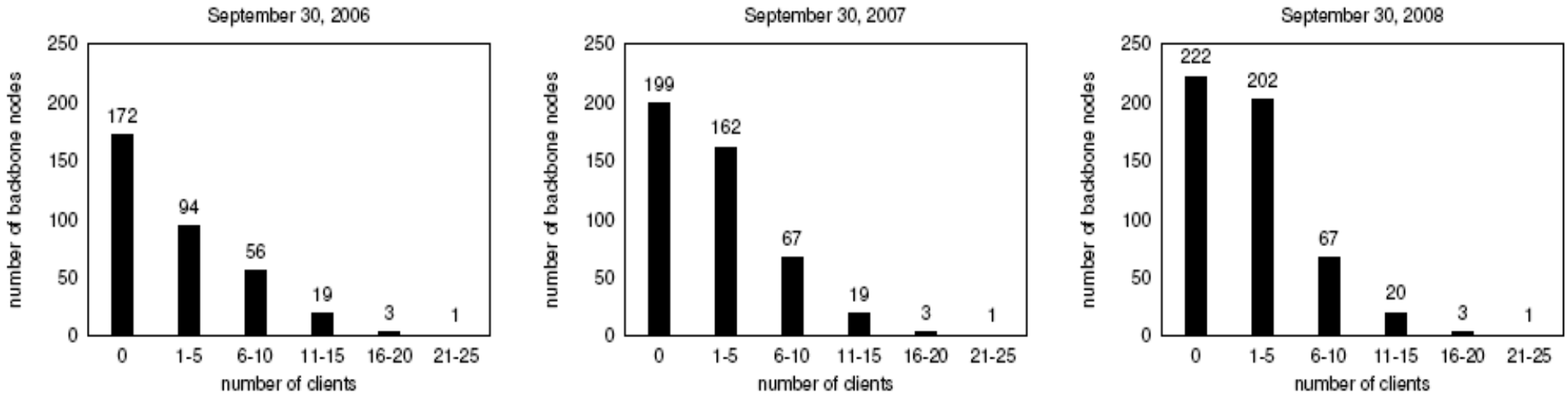


Diameter of the Network



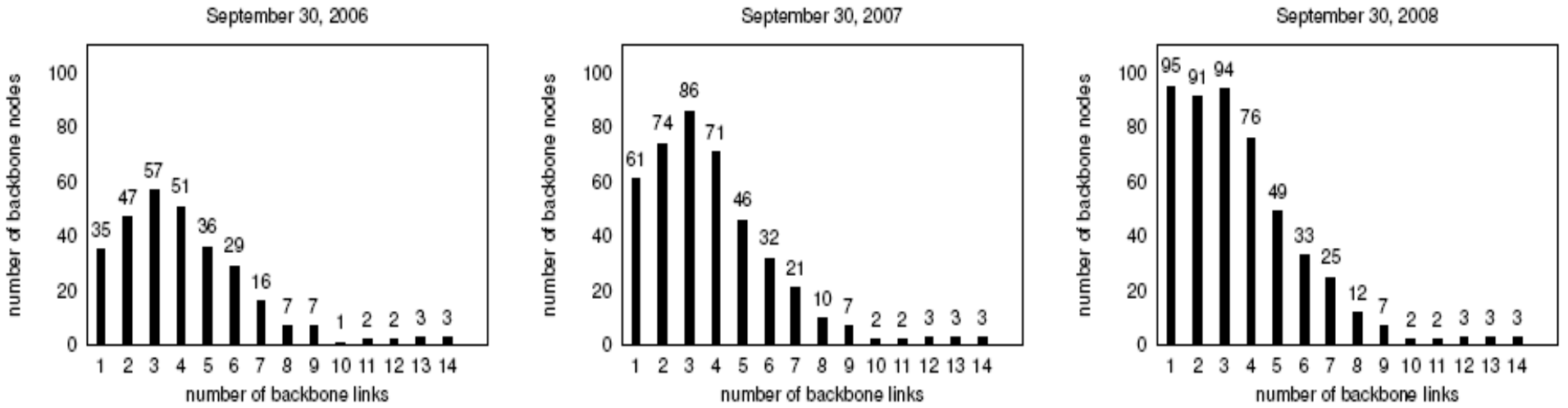
- We ran traceroute commands from 5 different spots in Athens
  - Diameter based on our traceroute is 9,5
- Diameter was calculated according to the links registered in WiND
  - Diameter based on WiND is 8,2
  - Maybe more accurate, because it takes into account every link

Distribution of Clients (per Backbone Node)



- Many backbone nodes to not support any client nodes
  - Client nodes seen as not contributing much to the network
  - They increase its size and are potential future backbone nodes

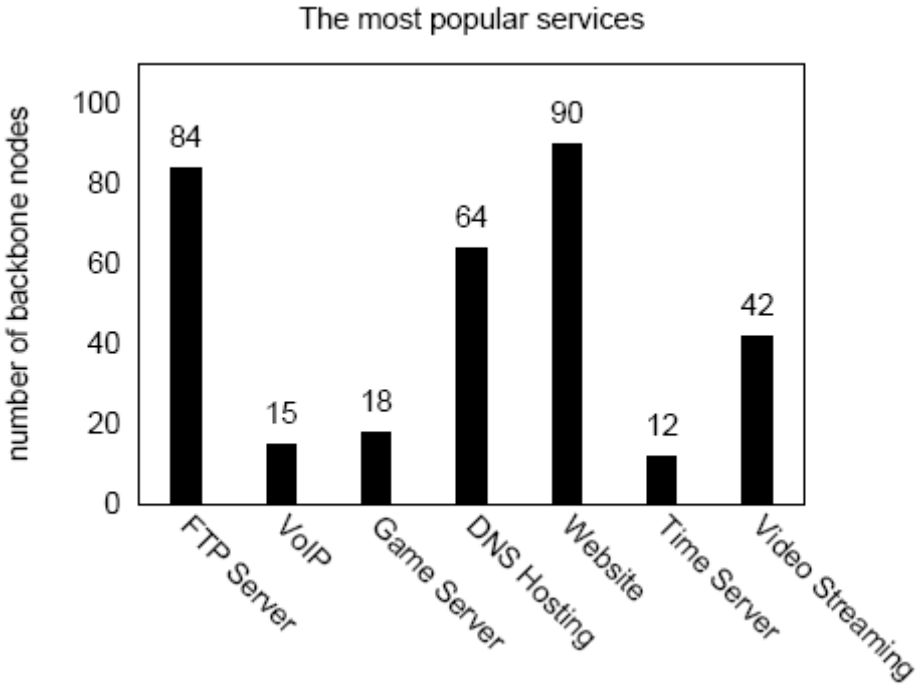
Distribution of Links (per Backbone Node)

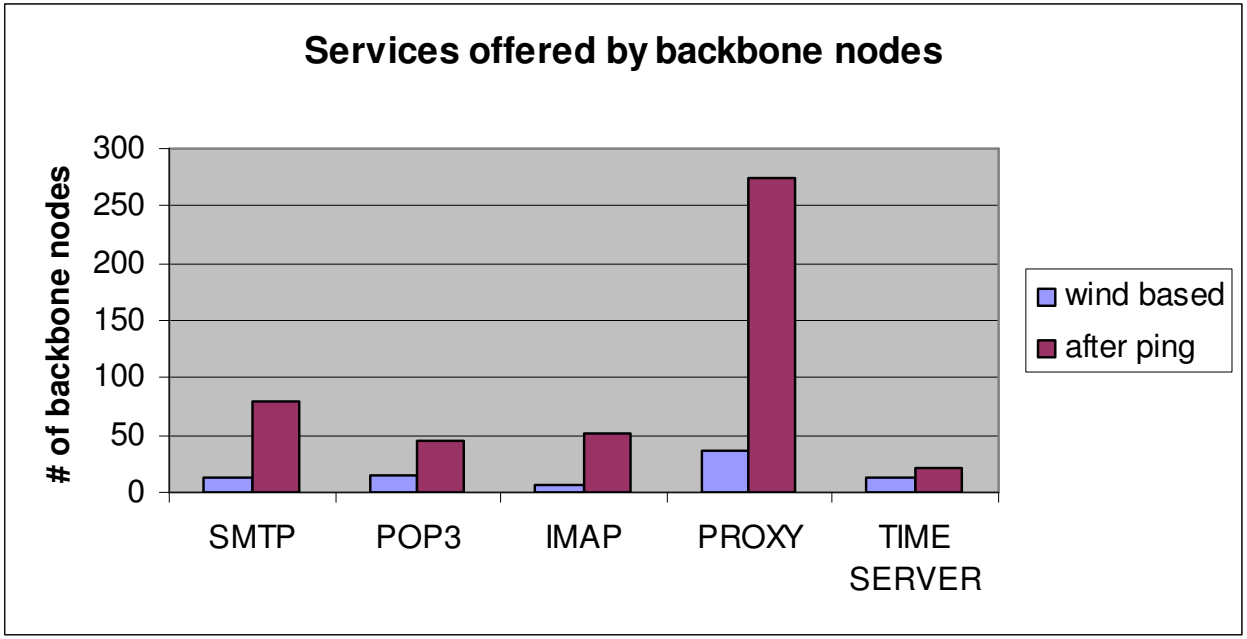


- The average **out**degree is 1,58
- Most backbone nodes have 3 links with other peers
- Connectedness and reliability
  - If one node fails, part of the network is not isolated, as there are often other links and alternative paths

Most Popular Services

- We examined whether some of the registered services are indeed provided
- We noticed that the number of nodes that indeed provide a service is larger than the number registered in WiND





- Proxy service (when a node shares its fixed broadband connection with the rest of the network) is not always for public use

Topological Statistics of AWMN–Power Laws Comparison to the Internet during the 90s

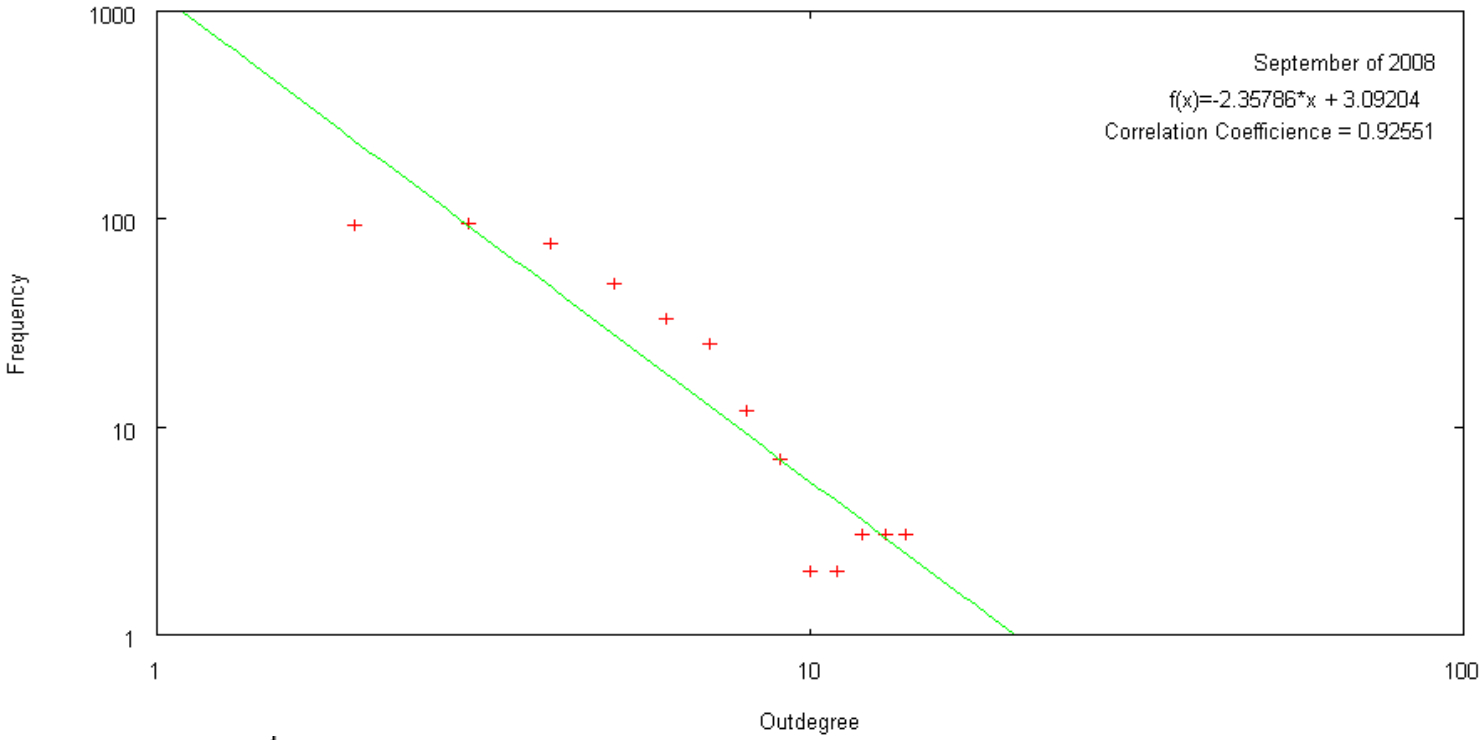
- Attempted to model the AWMN topology through 3 power laws
  - Frequency of the Outdegree
  - Rank of the node in decreasing order of Outdegrees
  - Neighborhood size in specific hops
- They help us answer some important questions
  - What does AWMN look like?
  - Are there some topological properties that do not change in time?
  - How will it look like in a year?

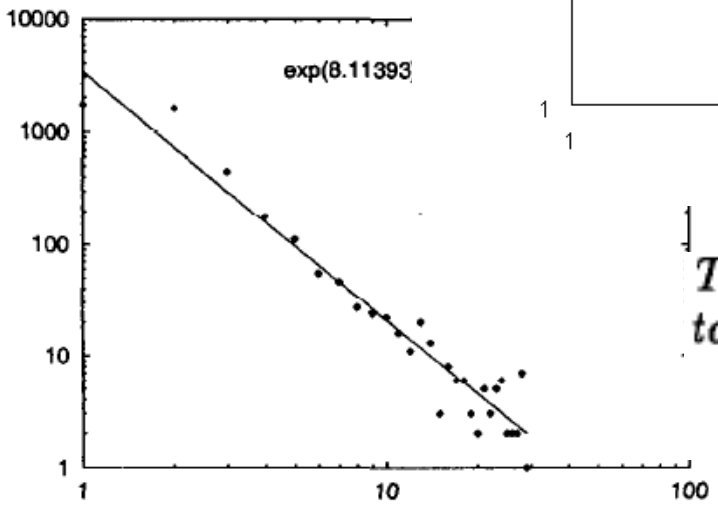
- These power laws were identified for the Internet during the 90's

  Michalis **Faloutsos**, Petros **Faloutsos**, Christos **Faloutsos**, "On Power-law Relationships of the Internet Topology," ACM SIGCOMM 1999.

- A potentially significant similarity(?) between the 2 networks

Frequency of the Outdegree





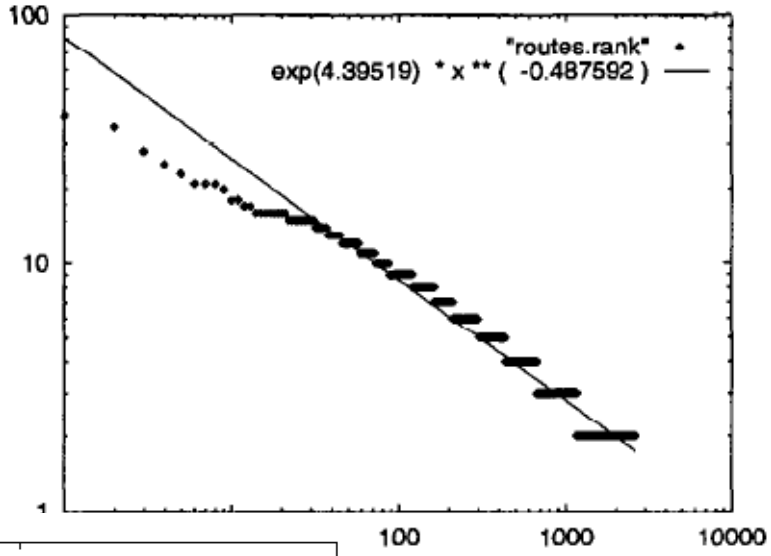
The frequency, f_d, of an outdegree, d, is proportional to the outdegree to the power of a constant, $\mathcal{O}$:

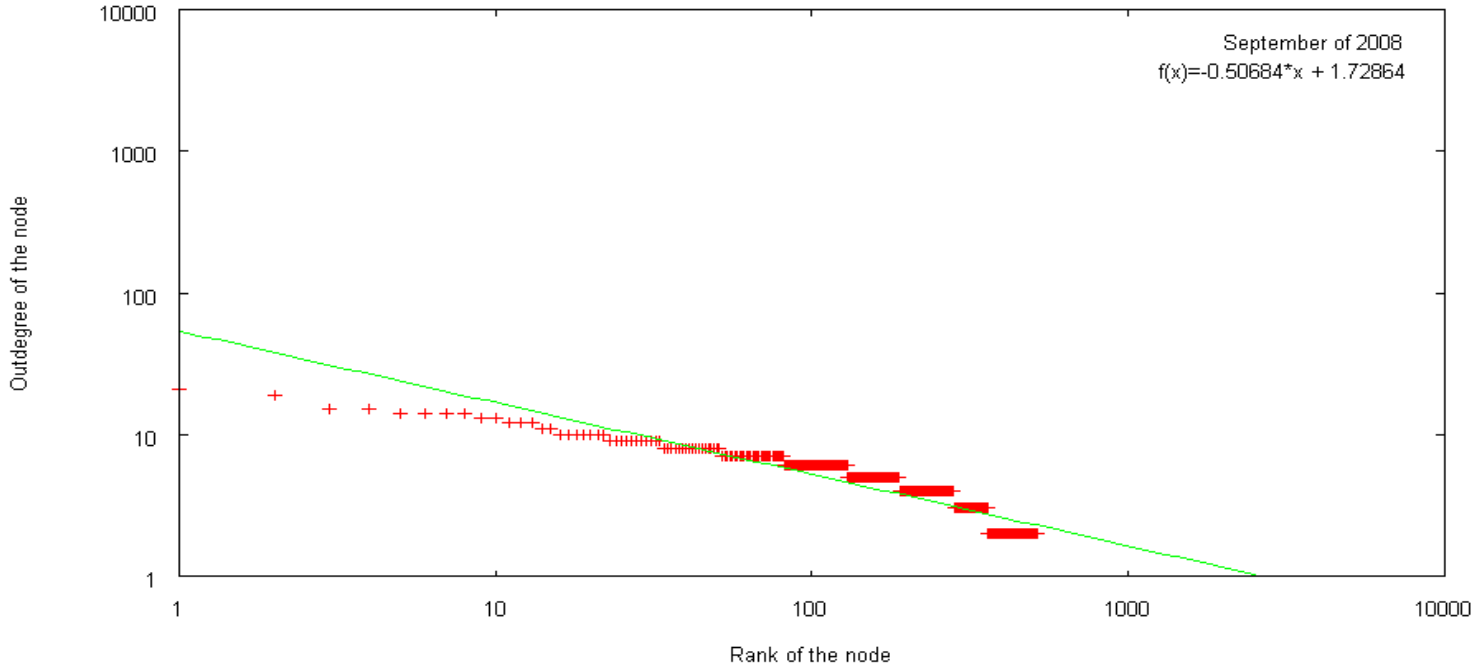
$$f_d \propto d^{\mathcal{O}}$$

Rank of the nodes in decreasing order of Outdegree

Power-Law 1 (rank exponent) *The outdegree, d_v, of a node v, is proportional to the rank of the node, r_v, to the power of a constant, $\mathcal{R}$:*

$$d_v \propto r_v^{\mathcal{R}}$$

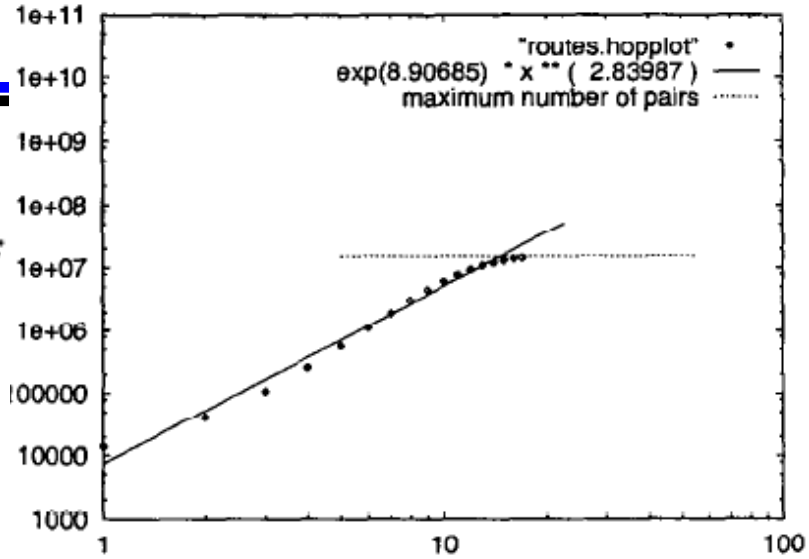


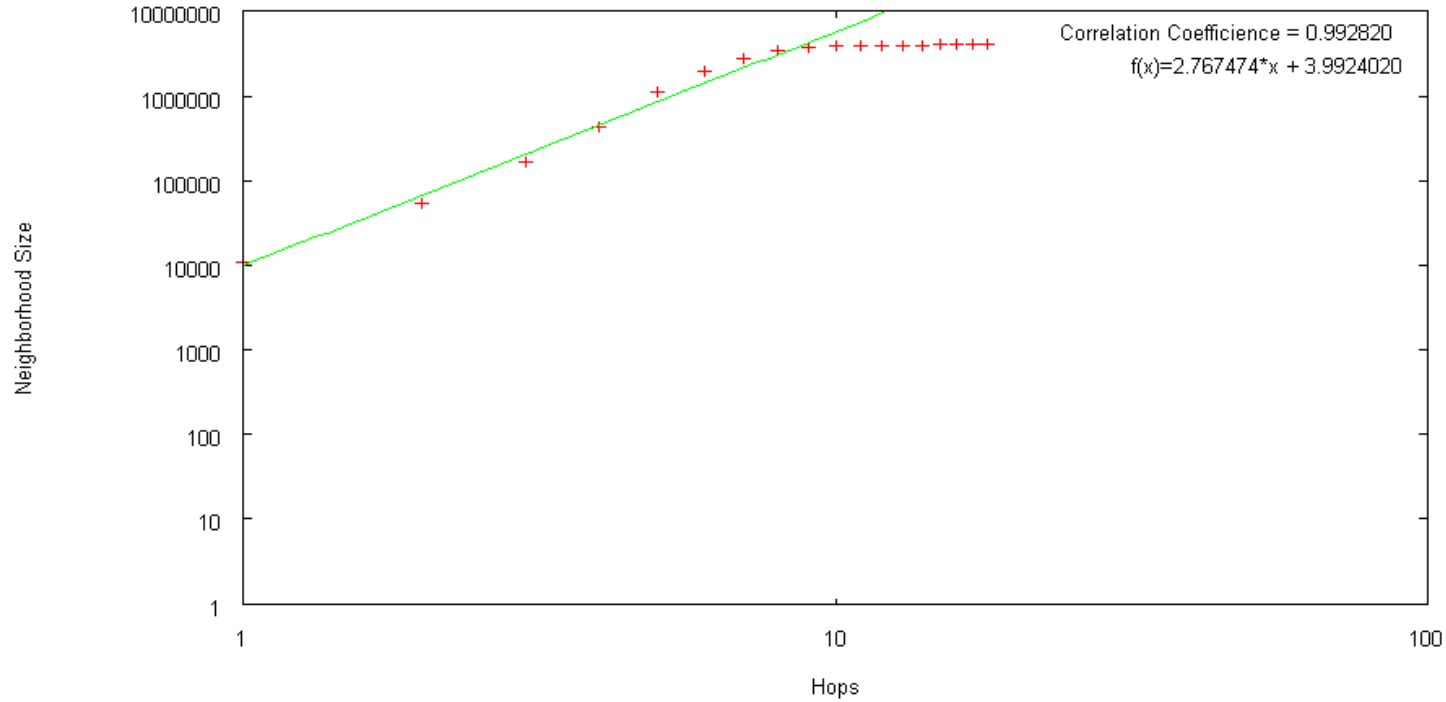


Neighborhood Size at a specific Hops-count

Approximation 1 (hop-plot exponent) *The total number of pairs of nodes, $P(h)$, within h hops, is proportional to the number of hops to the power of a constant, $\mathcal{H}$:*

$$P(h) \propto h^{\mathcal{H}}, \quad h \ll \delta$$





Comparison to the Internet

- Similarities
  - AWMN resembles the Internet in addressing and routing
  - The services provided are a subset of those on the Internet
  - Free Services (all in AWMN, many on the Internet)
  - We have identified 3 Power Laws
    - that apply to the Internet topology during the 90s and
    - may be argued that they also apply to AMWN
- Differences
  - Internet is much larger than AMWN
  - ISP charges--AWMN participation is free
  - no central repository of information about the whole Internet, while there is WiND for AWMN
  - the Internet can be used for profit, while AWMN is always not-for-profit

Thanks!

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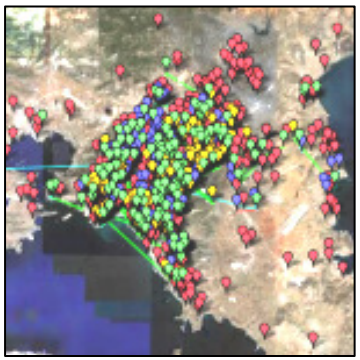

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