IPv6 Primer for Sensor Networks

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Credentials

- 20+ years in IP networking and Unix
- 10 years on IPv6
- Wrote IETF drafts and RFCs
- Wrote the "Migrating to IPv6" book.
- Gave IPv6 tutorials at many conferences. Authored and delivered the Cisco IPv6 course.
- Co-founder and member of the board, IPv6Forum
- Member of steering group of North American IPv6 Task Force
- President of Viagénie, consulting in networking

Changing World

- Host used to be a large, fixed computer. Now: a cell phone, a tiny sensor, an id tag on a cow, etc...
- Host used to be client of services on servers. Now, peer-to-peer.
- Host used to have a single interface. Now, a PDA or laptop or 3G cell phone is a router.
- Devices used to be static. Now mobile, moving using different link-layer technologies.
- Networks are mobile: an airplane network.

Changing World (cont.)

- A network used to be managed by a full-time professional. Now a network with plenty of users, services and computers is in the home, without a “professional”....
- Access networks are diverse: Fixed Ethernet, Wifi, 3G, WIMAX, etc... Bandwidth has increased by 1 000 000 times per user.
- The Internet used to be a trusted place for science people to share information. Now, the trust of the network is near zero.

Changing World (cont.)

- IPv4 was not designed with these assumptions. IPv6 is based on these assumptions.

Why IPv6?

- Initially (early 90's):
  - Lack of IPv4 address space
    - Studies show no more address space between 2005-2011, depending on growth rate
  - Scaling of global routing
    - Too many routing entries, given the lack of aggregation.

Why IPv6? Reality

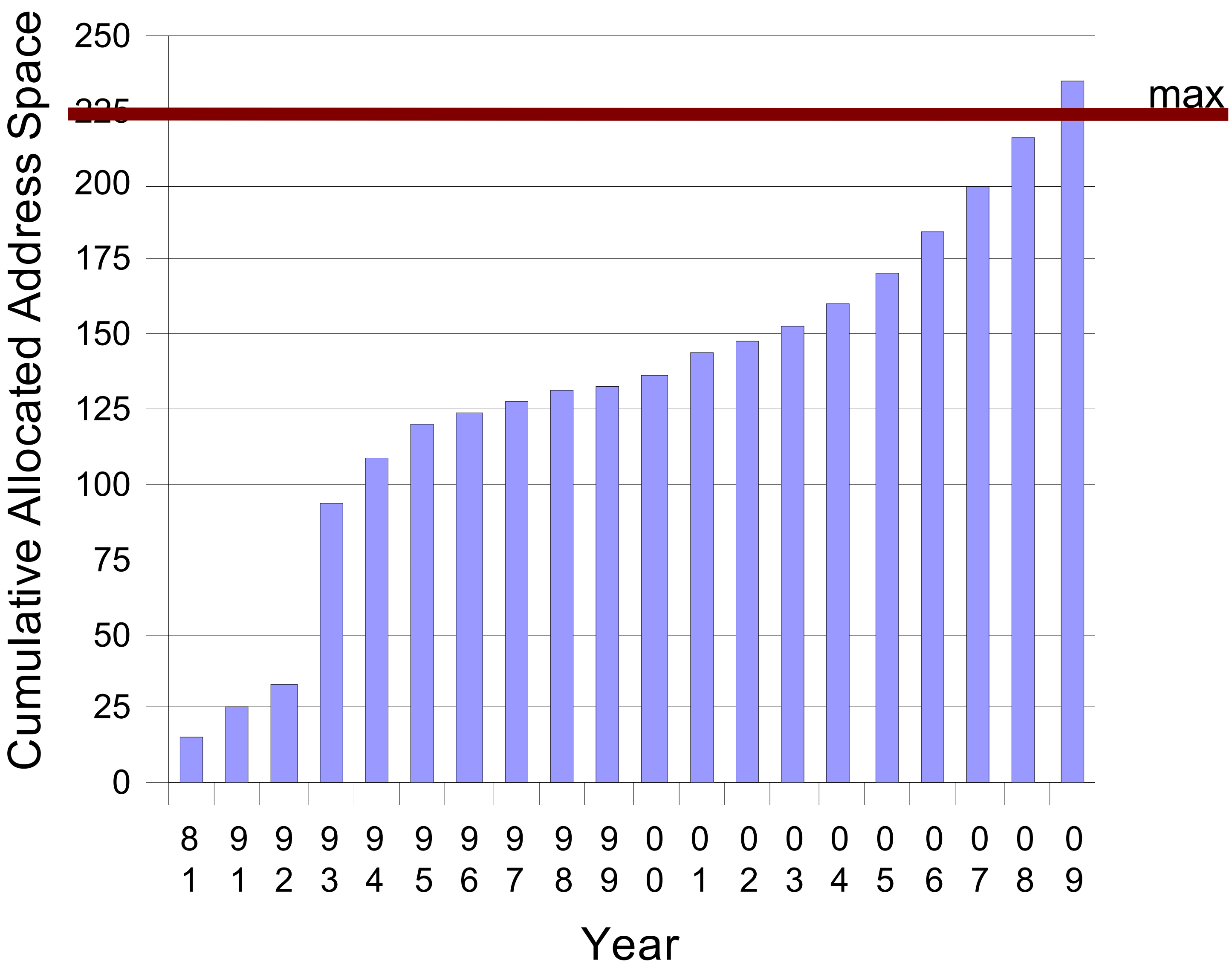
- IPv4 address space
  - Despite continuous growth, consumption rate was mitigated by many factors/technologies, such as: NAT, HTTP 1.1, etc... So we bought time, but time is running up!
- Scaling of global routing:
  - improvements in implementations put this issue on the backburner for some time, while not fixed.

Why IPv6 Now?

- With IPv4 Address space:
  - No reachability of end nodes
  - Can not deploy applications. Skype is the confirmation!
  - Network management costs are increasing substantially.
    - Merging two enterprise networks is an interesting problem these days...
  - Address space for large deployments (internet-late-large population countries, wireless/cell networks) are not possible
  - And yes, IPv4 address space is really running out.
- IPv6 address space fixes all these issues.

IPv4 Address Space

- With 20%/year growth rate



Why IPv6 Now? (cont.)

- IPv6 new functionalities required by applications
  - Much much larger address Space
  - Autoconfiguration
    - Ability to configure a node automatically with minimal help from a server infrastructure
    - embedded, tiny nodes, sensors, etc...
  - Mobility
    - Ability to move to different networks while keeping the communications up
  - IP Security from/to end nodes
  - Multihoming
    - Capability for a node or network to be connected to multiple (provider) networks
  - Optimizations, scalability, performance, simplicity
  - etc.

IPv6 in a nutshell

- Larger address space: from 32 bits to 128 bits
  - Large scale deployments with end node reachability are possible
  - Easy numbering and addressing plans
  - Unique private address space for each organisation:
    - Enables private address space used without any issue later when merging or connecting other private networks

IPv6 in a nutshell (cont.)

- Mobility
  - Capability of mobile node to move to another IP network (by switching to another link-layer technology, or switching to another subnet) without interrupting any on-going communications
- Security
  - Given restored end node reachability, ability to deploy IP security end to end.
- Mobility and security can be combined together.

IPv6 delivers IP reachability

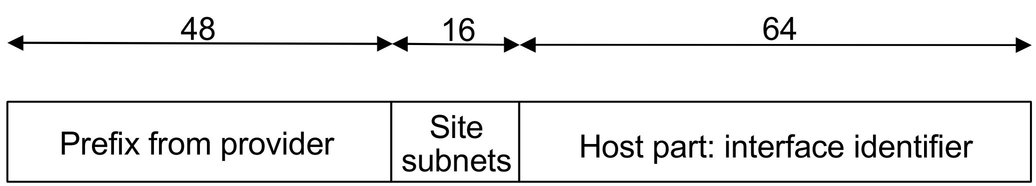
- With a large address space to address any number of devices
- With autoconfiguration to automatically configure end nodes
- With automated network services, such as prefix delegation to networks

IPv6 Header

- New IP header
  - Version field = 6
  - Source and destination address fields = 128 bits each
  - Moved options to extensions headers (simpler, more efficient for routing)
  - Simpler than IPv4 header
  - Can be compressed (much more than IPv4 header) down to 1-2 octets.

IPv6 Addressing

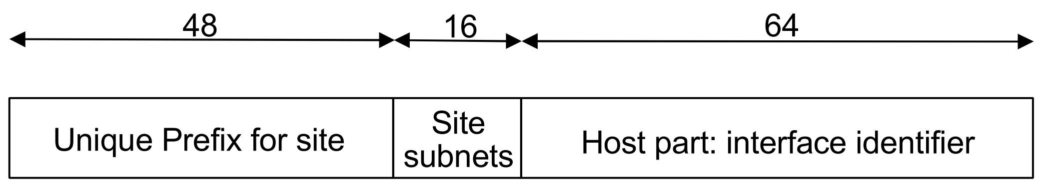
- 128 bits
- Unicast



  - Global
  - Private, site scoped (i.e. enterprise)
  - Link scoped
- Multicast
- Interfaces have multiple addresses

IPv6 Private Address Space

- Named: Unique Local



- Unique to the enterprise
  - No future conflict with another network
  - Easy to merge, connect networks
  - In addition to the global address space

Configuring a Node

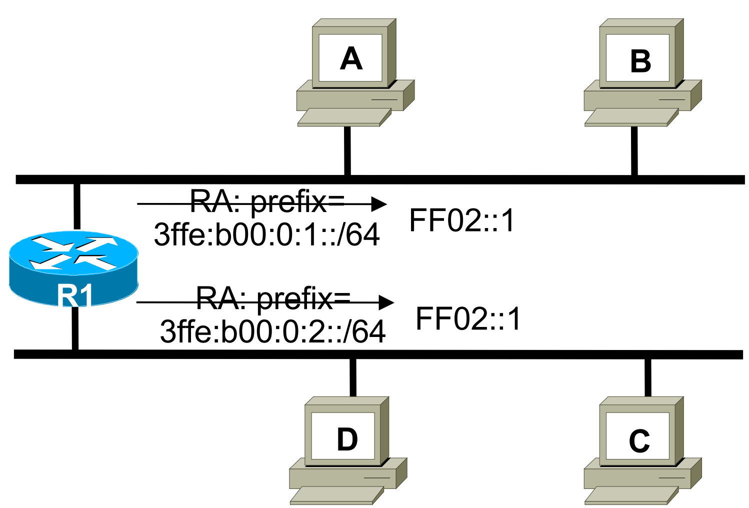
- As soon as an interface is up, an IPv6 address is locally and automatically configured on the interface. The link-local address is used for communications with other nodes on the same link/subnet.
- all IPv6 nodes on the same subnet can communicate peer-to-peer without the need of an infrastructure server or router.

Configuring a Node (cont.)

- An IPv6 node can be configured using:
  a) Static IPv6 address (as in IPv4)
  b) A DHCPv6 server (as in IPv4)
  c) Autoconfiguration
    - Address has two parts:
      - Network ID and host ID
    - Host ID is made from the MAC address.

Autoconfiguration

- Network ID:
  - Routers on the subnet send network ID (prefix) to the nodes (router advertisements). Nodes then use their MAC address from the interface and concatenate the prefix to create the full IPv6 address.



Mobility

- Mobile node has a “permanent” address (named home address)
- Mobile node receives a temporary address when it is visiting a network. Mobile node has 2 addresses.
- Mobile node advertises its temporary address to all its peers and to its “proxy” (home agent).
- Traffic is sent directly to the current location of the mobile node.
- On-going communications continue to work even if the node is moving.

Deployment considerations

- Typical deployment is dual-stack:
  - Both IP versions are running in hosts, applications, network.
- Except high-end routers, software upgrade. Recent OS are Ipv6-ready.
- Applications need to be converted to IPv6
- Access networks can be deployed at the beginning using IPv6 in IPv4 tunnelling
- Don't need to upgrade everything at the same time.

IPv6 over IEEE 802.15.4

- IETF working group: 6lowpan.
- Specification draft: Transmission of IPv6 Packets over IEEE 802.15.4 Networks, draft-ietf-6lowpan-format-02
  - Defines how to map IPv6 packets in IEEE 802.15.4 frames
  - IPv6 packets are carried in ack'ed data frames
  - Uses header compression (to 2 octets)
  - Supports both 16 or 64 bits 802.15.4 addresses
  - 1 Pan ID = 1 IPv6 link (subnet)

IPv6 over IEEE 802.15.4 (cont.)

  - IPv6 packets are fragmented before put in a data frame.
- Deployment scenarios:
  - Each sensor uses IPv6 over IEEE 802.15.4
    - Has IP reachability, can be managed, can send/receive data from a far remote network.
  - A gateway between the IEEE 802.15.4 and the IPv6 network
    - Only the gateway implements IPv6.

Case Study: Comcast

- Control plane: active management of cable modems, set-up boxes and other devices in the customer premises. Private network.
- Need of 100 millions addresses just for control plane (not taking into account user's address space). IPv4 private address space is just not enough.
- Deploying IPv6 is the only way to solve this problem.

Case Study: DoD

- Needs:
  - Host Mobility
  - Network mobility
  - Security
  - End-to-end reachability
  - Large addressing space
  - Autoconfiguration
  - ...

US Policies

- Since 2003, DoD mandating IPv6 support for products and migrating networks and applications to IPv6 by 2008.
- 2005, US governement (Office of Management and Budget(OMB)) mandating deployment for all agencies by 2008.
  - 2006:
    - provide complete IPv6 transition plan
    - Complete impact analysis
  - 2008: Federal agencies implement IPv6 on their network backbones.

Case Study: Japanese ISP

- Application: access to home network services (media, chat, etc...) from internet, using cell phone or any device
- IPv6 provides reachability to the home network, securely.

IPv6Forum

- International Consortium of ~200 organisations: Vendors, Users, Providers, etc...
- Developing a Vision 2010 roadmap:
  - Delivering ROI
  - Deployment of Peer-to-Peer
  - Integration of real-space and cyberspace
  - Mobility, End-2-End security
  - Ease of O&M
- http://www.ipv6forum.com

Conclusion

- IPv6 is a new version of IP.
- It provides:
  - Addressing, reachability, ease of deployment
  - Autoconfiguration
  - Mobility
  - End-to-end security
  - Support for tiny nodes, embedded and the like

Questions?

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References

- Marc Blanchet, Migrating to IPv6, Wiley, 2006, ISBN 0-471-49892-0
- Transmission of IPv6 Packets over IEEE 802.15.4 Networks, draft-ietf-6lowpan-format-02.txt