IPv6, IETF, and Mobile Networking

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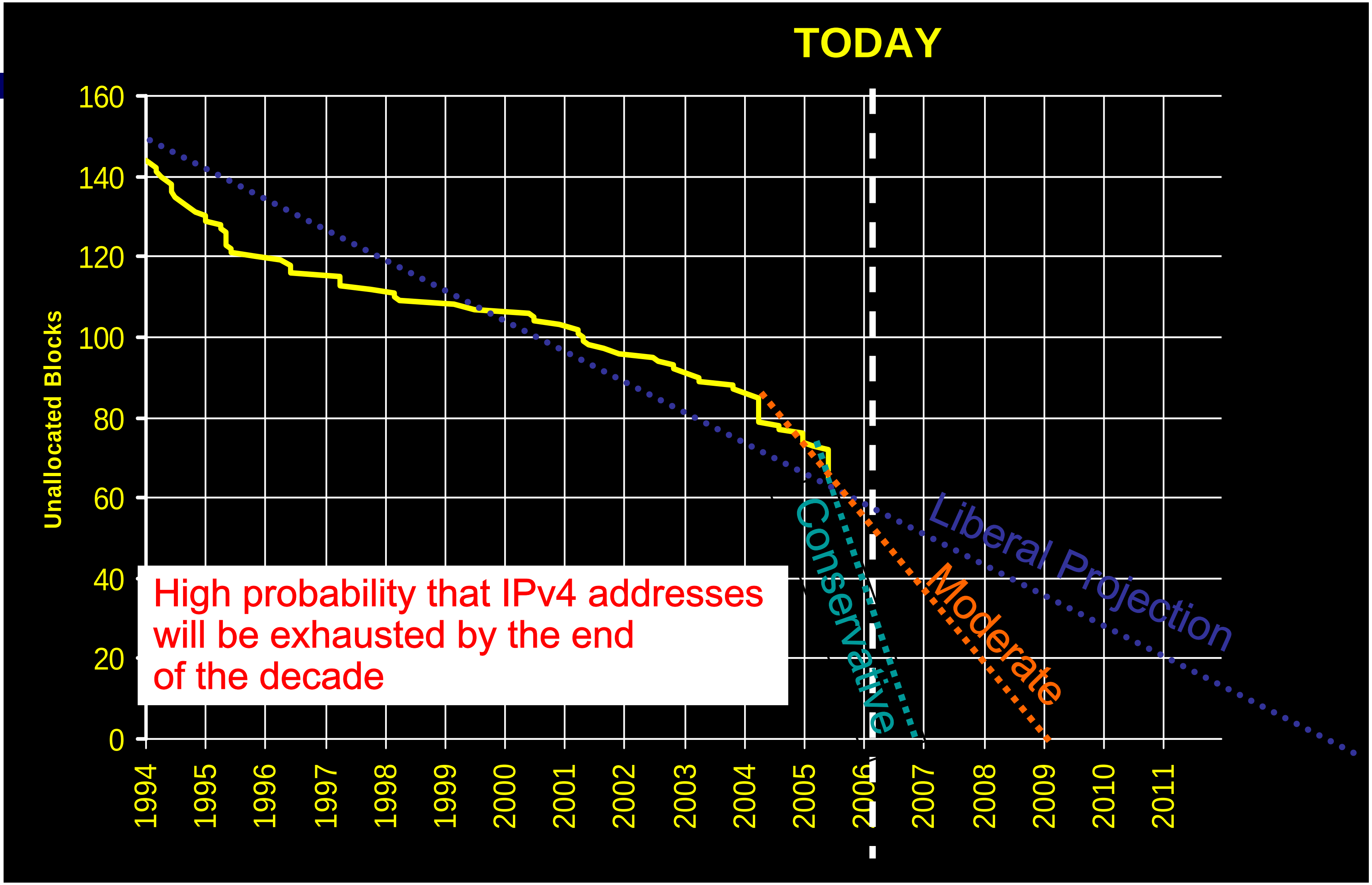
Outline of Presentation

- IPv4 address space exhaustion
- IPv6 in General
- IETF and relevant working groups
- Mobile IPv6
- Ad Hoc Networking

Earth with Billions of Mobiles

- One billion is a large number, but we are way past that
- We are navigating uncharted waters
- In the beginning, most phones weren't Internet enabled, but they are coming online rapidly
- IPv4 can do it but at a tremendous cost in complexity
- Only IPv6 offers enough addresses; Internet is young!
- IPv6 offers features needed for mobile networking
  - Mobile IPv6 takes advantage of them to offer seamless mobility.
- Network-layer mobility could enable significant cost reductions and improved deployability

Remaining /8 IPv4 IANA



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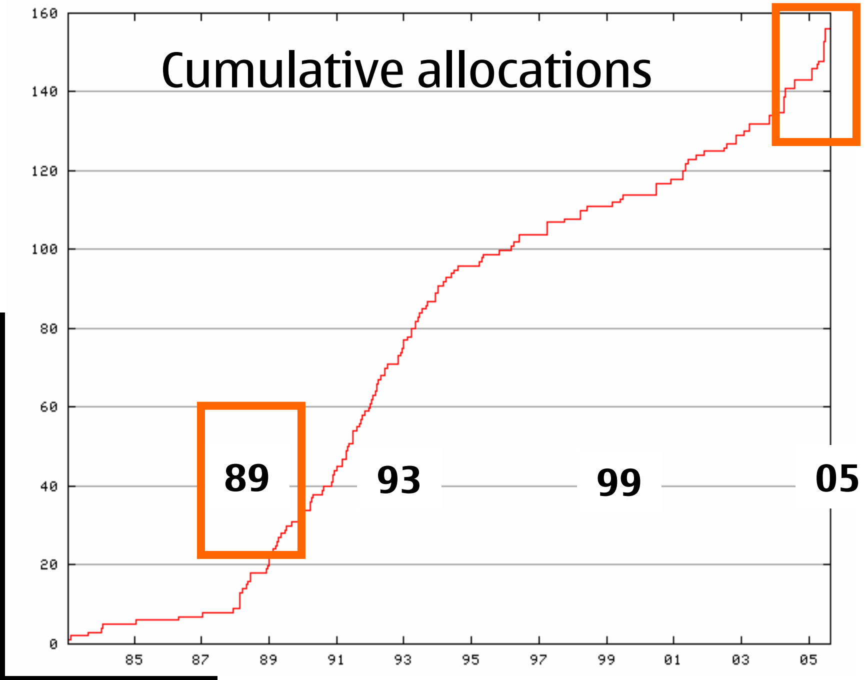
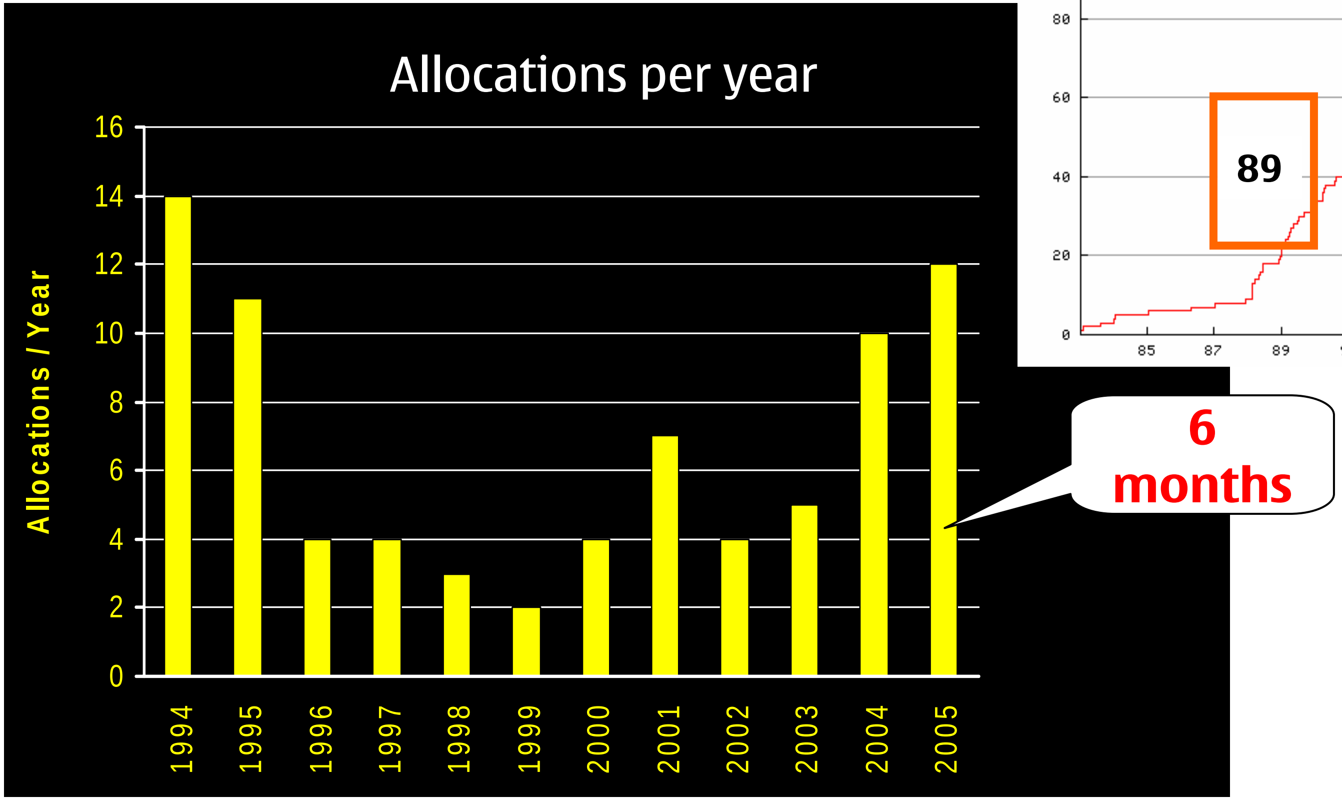
IANA Allocations to RIRs





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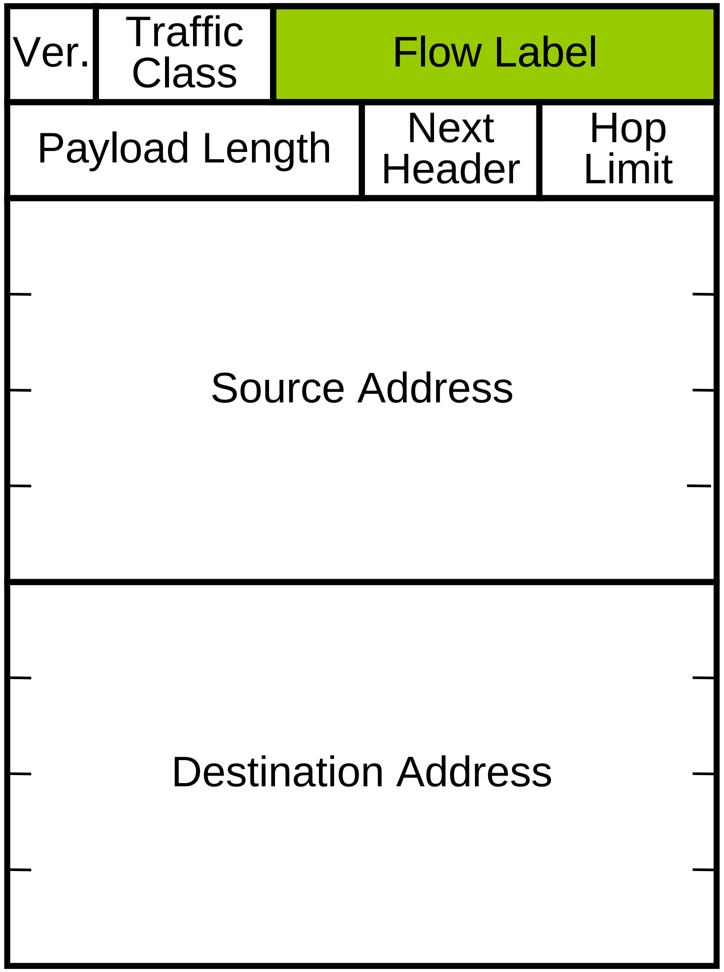
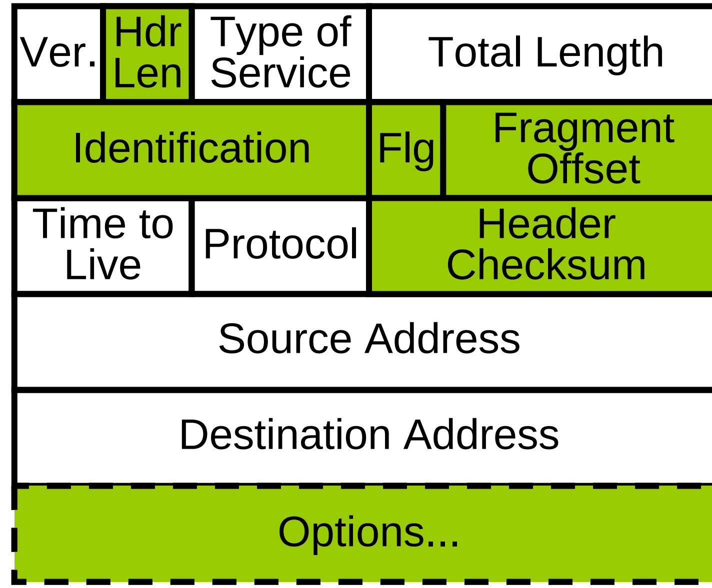
IPv6: It’s not rocket science





shaded fields have no equivalent in the other version

IPv6 header is twice as long (40 bytes) as IPv4 header without options (20 bytes)

Enough Addresses

- 340 undecillion addresses
  - (340,282,366,920,938,463,463,374,607,431,768,211,456) total!
- We'll have perhaps tens of billions of IP-addressable wireless handsets and devices over the next 20 years
  - Even more IP addresses needed for embedded wireless!
- IPv4 address space crunch driving current deployment of NAT
  - NAT makes *always on* operation (e.g., VoIP) difficult
  - NAT hurts applications, and obstructs new applications
  - NAT is a serious power drain
- IPv6 especially interesting for China now
  - 22 million IPv4 addresses and 350+ million handsets

IETF mantra

Rough consensus and running code

- Consensus requires persistence and team-building
- Running code requires sweat and interoperability

IETF structure

IETF has Areas and Area Directors (ADs)

IETF has over 100 working groups:

- General Area (AD is IETF chair)
- Applications Area
- Internet Area (most mobility groups here)
- Operations and Management Area
- Routing Area ([manet] is here!)
- Security Area
- Transport Area

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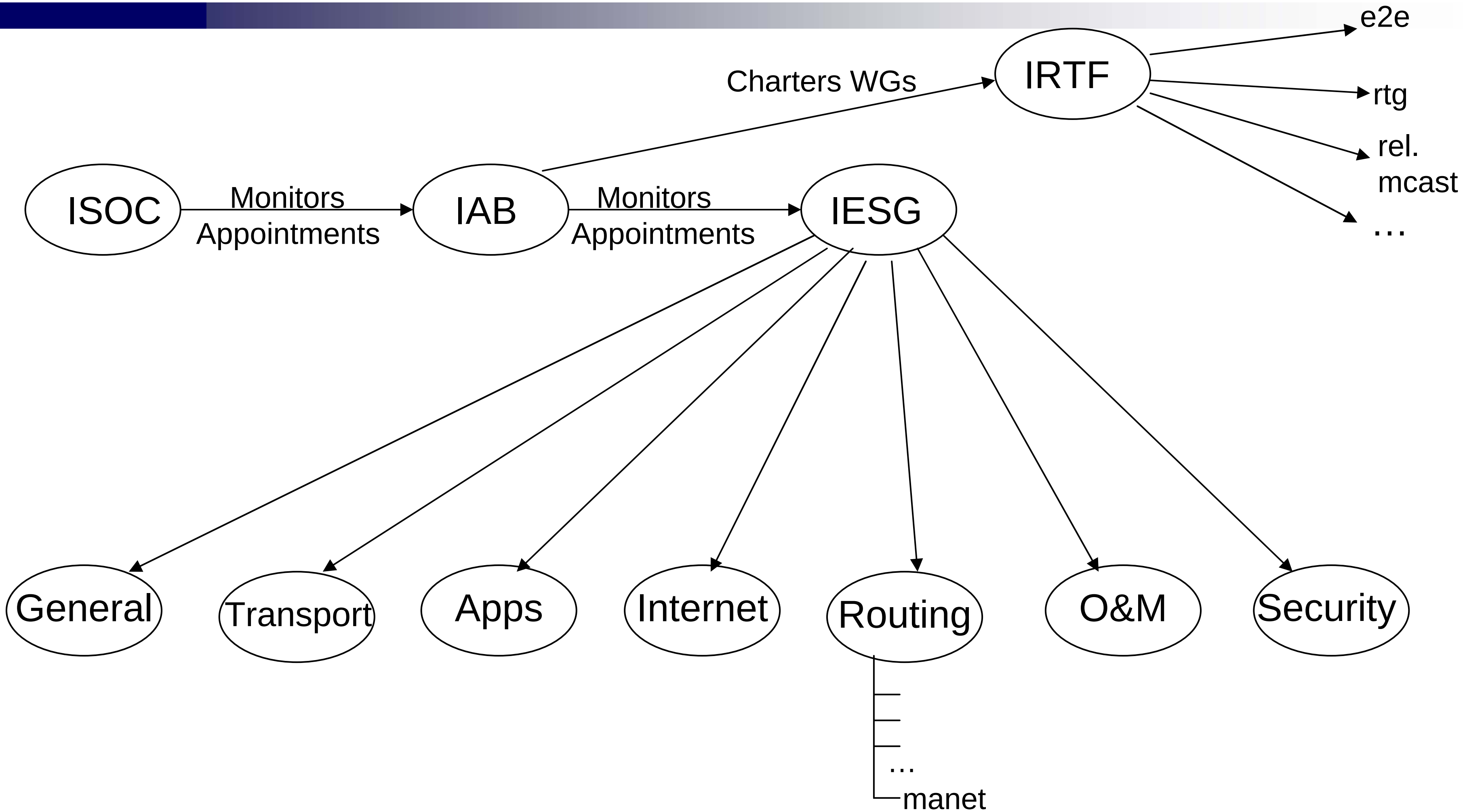
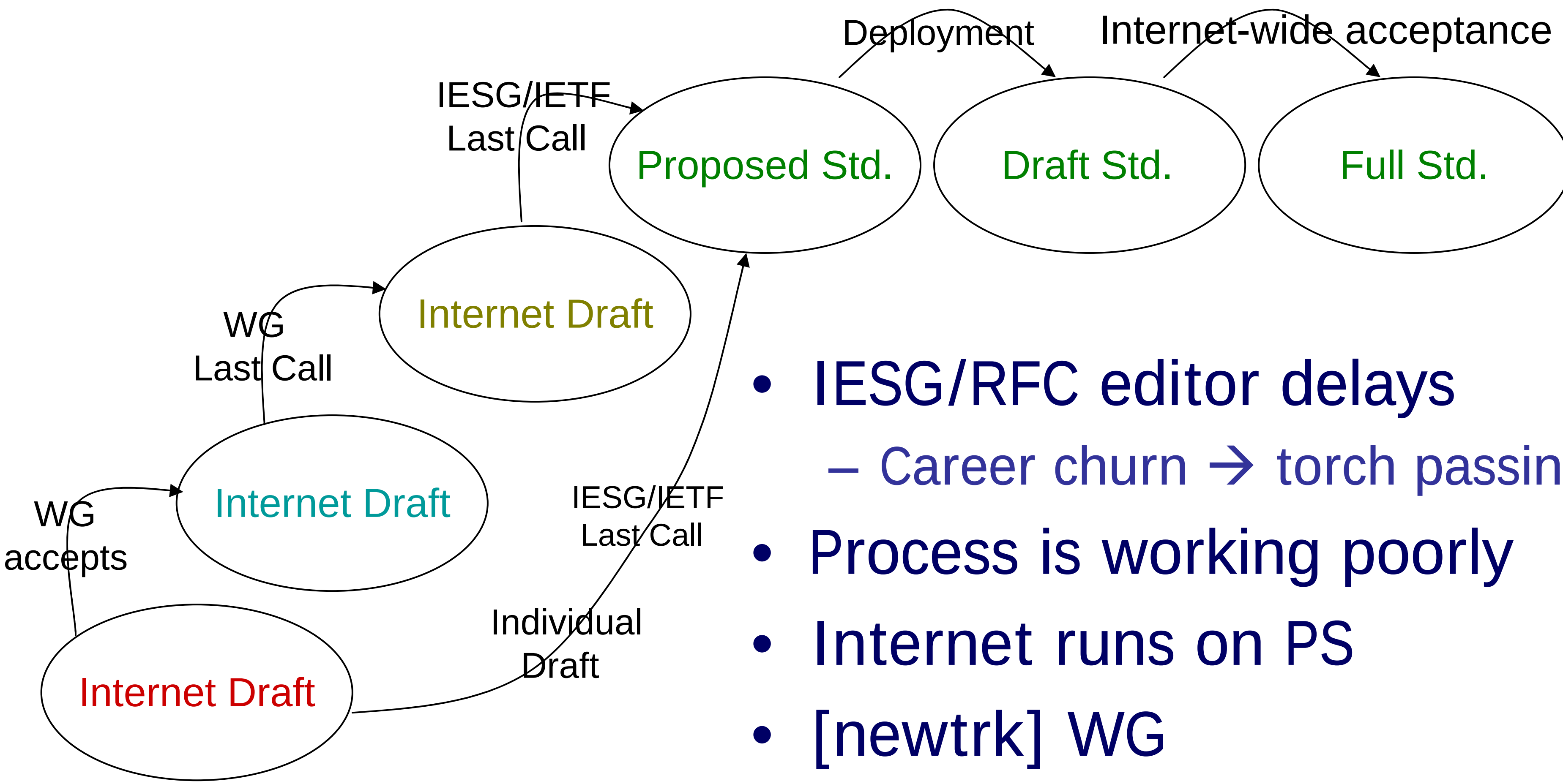
IETF Organizational structure



IETF process (theoretically…)



- IESG/RFC editor delays
  - Career churn → torch passing
- Process is working poorly
- Internet runs on PS
- [newtrk] WG

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v6-related IETF working groups

- ipv6
- mip6
- mipshop
- monami
- dna
- nemo
- autoconf / manet
- netlmm

- 6lowpan
- shim6
- softwire
- seamoby
- send

IRTF:

- mobopts

This is a huge amount of effort overall

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IPv6 protocol documents

- RFC 1887: Address architecture
- RFC 2460: IPv6 Protocol specification
- RFC 2461: Neighbor discovery
- RFC 2462: Stateless Address Autoconfiguration
- RFC 3315, RFC 3736 - DHCPv6, Stateless DHCPv6
- RFC 2406: Encryption (privacy)
- RFC 2402: Authentication
- RFC 3775: Mobile IPv6
- RFC 3041: Randomized address configuration
- RFC 4193: Unique Local Unicast Addresses
- RFC 4213: Basic transition mechanisms
- RFC 39xx: Cryptographically Generated Addresses
- Dozens more... Plus, quite a few more almost done

Mobile IP: what is it?

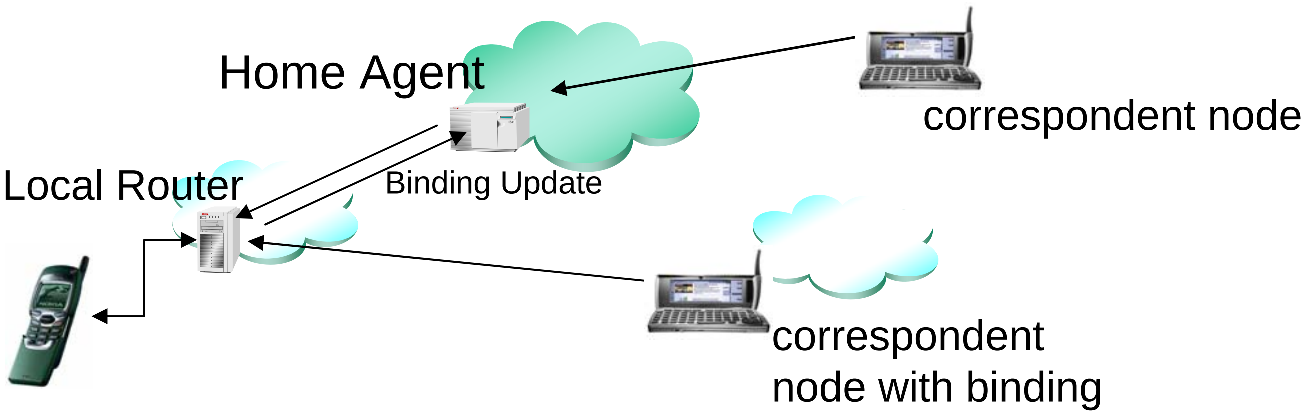
- Both ends of a TCP session (connection) need to keep the same IP address for the life of the session.
  - The *home address*, used for end-to-end communication
- IP needs to change the IP address when a network node moves to a new place in the network.
  - The *care-of address*, used for routing

Mobile IP models the mobility problem as a *routing* problem

  - managing a *binding* – that is, a dynamic tunnel between a care-of address and a home address

- *Of course*, there is a lot more to it than that!
  - service discovery, session persistence, context xfer,…

Mobile IP protocol overview



- Routing Prefix from local Router Advertisement
- Address autoconfiguration → care-of address
- Binding Updates → home agent
  - (home address, care-of address, binding lifetime)
- *Seamless Roaming*: Mobile Node “*always on*” home network
- correspondent nodes → BindingUpd [“*Route Optimization*”]

Floor wax or ice cream dipper?

- IP address – what is it?
  - Locator?
  - Identifier?
  - For fixed nodes, it never mattered
- All mobility schemes need stable identifiers
  - NAI, HIT, DNS, TMSI, IP address, MAC addr., URI, Session ID, ...
  - Distributed vs. centralized directory lookup
  - IP address seems to offer a unique advantage: the *identifier* automatically locates the *directory*

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IPv6 basic features in Mobile IPv6

- Enough Addresses
- Enough Security (well, almost)
- Address Autoconfiguration: care-of addresses
- Destination Options (and, now, Mobility) extension headers
- Multicast, Anycast
- also, reduced Soft-State, MIBs, etc.

Route Optimization

- Almost all future Internet devices to be mobile or wireless
- *SHOULD* implement Binding Update in all IPv6 nodes
- Reduces network load by ~50% (depending on traffic model)
- Route Optimization "could" double Internet performance
  - reduced latency
  - better bandwidth utilization
  - reduced vulnerability to network partition
  - eliminate a potential Home Agent bottleneck
- Downside: authentication is *required* but *nontrivial*

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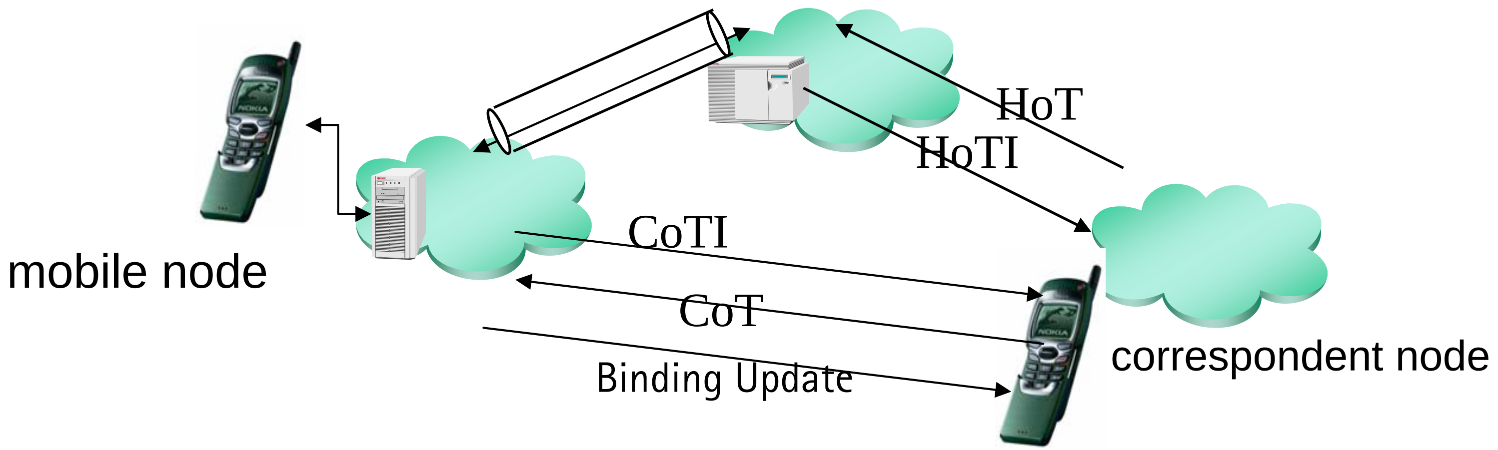
Establishing a Binding Security Association

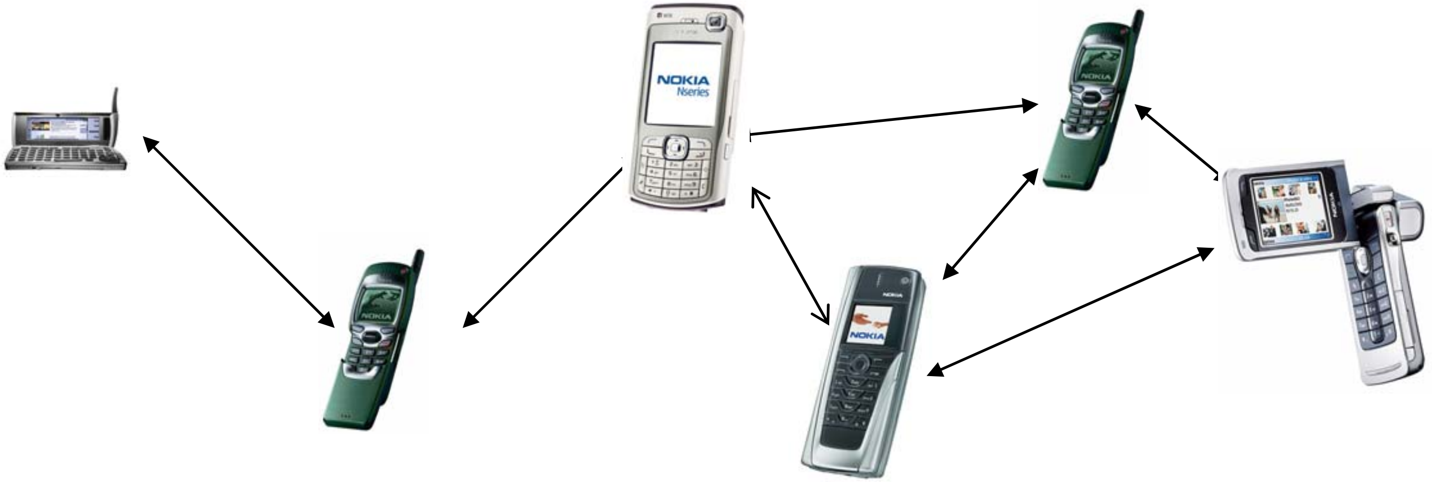
- BSA is needed for authenticating Binding Updates
- "First, do no harm"
  - As safe as communications of motionless IPv4 nodes
  - Only nodes between correspondent node and home network can disrupt traffic
- Return Routability (RR) relies on routing infrastructure
- Mobile IPv6 RR enables *authentication,* not *identification*
  - Latter could require validation via *certificate authority*
  - Correspondent node only it is the same node as before
- RR solution resists Denial of Service (DoS) attacks

RR Protocol Overview



- Test return routability for home address (HoTI, HoT)
- Test return routability for care-of address (CoTI, CoT)
- HoT and CoT carry nonces to be combined to make K*bu*
- Very few nodes see nonces in both HoT and CoT
- BSA in current specification is short-lived
- Correspondent node keeps no *per-mobile* state during HoT/CoT

Ad Hoc Network characteristics



- peer-to-peer
- multihop
- dynamic
- *Really* "anytime, anywhere"
- zero-administration
- low power
- autonomous
- autoconfigured

But, most of these have exceptions!

Ad Hoc nodes & IPv6 addressability

- IPv6 offers enough addresses for the coming billions of wireless devices
- Ad hoc devices need zero-administration
- NAT boxes are notorious power drains
- IPv4 address autoconfiguration approaches are not at all trivial
- Ad hoc devices need reduced signaling
- IPv6 reduces or even eliminates complexity

Assured Address Uniqueness

- IPv6 => probable address uniqueness!
  - By construction from MAC address
  - By random selection
  - Optimistic DAD, e.g.
- This eliminates complexity and signaling
- Even more important for wireless
  - And even more so for sensor nets!
  - Better energy use:1 bit = 10,000+ CPU cycles

Ad Hoc Routing Projects

- Terminodes (EPFL)
- WINGs (JJ Garcia/UCSC)
- ROAM (JJ Garcia/UCSC)
- WAMIS (Gerla/UCLA)
- ODMRP (S.J. Lee/UCLA)
- TRAVLR (Kleinrock)
- Tora/IMEP (Park/UMD)
- Link Quality (Dube/UMD)
- LAR (Texas A&M)
- TBRPF/PacketHop (SRI)
- OLSR (Clausen/Jacquet)
- DSDV (Dest. Sequence #'s)
- AODV (refinement of DSDV)
- AOMDV (Multipath/Das et al.)
- LANMAR (Gerla et.al/UCLA)
- GPSR (Karp/Harvard)
- CBRP (Singapore)
- DSR (Dave Johnson, CMU)
- MMWN (Steenstrup/BBN)
- ABR (C.K. Toh)
- STAR (JJ Garcia/UCSC)
- ZRP (Zygmunt Haas/Cornell)
- Fisheye/Hierarchical (UCLA)
- CEDAR (Urbana-Champaign)

More Ad Hoc Routing Projects

- FRESH (latest encounter)
- ANTS(*swarm intelligence*)
- Ariadne
- Cryptographic Threshhold
- Insignia [QoS] (Columbia)
- AODV6
- FLR [“Feasible”] (UCSC)
- GPS/Geographic
- SHARP
- DMAC (Directional)
- Pulse
- TDR (Trigger based Distributive)
- DREAM
- SAODV (Guerrera)
- LDR (Mosko/Garcia …/Perkins)
- AODVjr(Chakeres/Klein-Berndt)
- WRP
- Minimum-energy approaches
- Compow
- Face Routing (GOAFR+,…)
- XTC (Topology Control)
- *Many* more…

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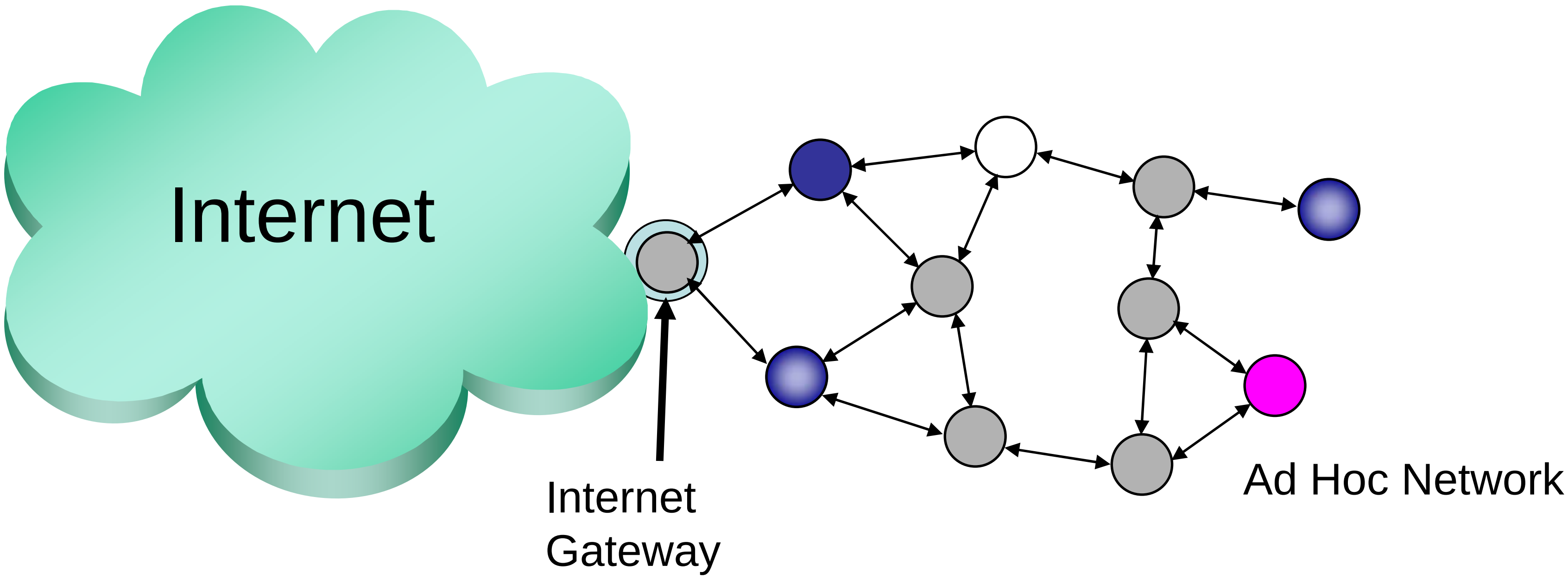
Mobile Ad Hoc Networking (*manet*)

- AODV: *on-demand*, and *distance-vector*
  - Interoperability testing
  - Experimental RFC 3561
- Other *on-demand* protocol is (DSR)
- Two link-state, *table-driven / proactive* protocols
  - RFC 3626: Optimized Link-State Routing (OLSR)
  - RFC 3684: Topology-Based Reverse Path Forwarding (TBRPF)
- DSR should also be published as Experimental
- Many other protocols have been considered!
  - For instance, quite a few of the previous list

[autoconf]

- Address assignment, as needed
  - Disconnected/isolated network case
  - Connected to Internet via a gateway
- Gateway provides routable address prefix
  - Allows packets to reach manet nodes
- Nodes can use permanent address with new care-of address in manet

Ad Hoc Stub Networks



- If any node has access to the Internet, then all nodes can have access.

Strategies for address allocation

- Random (works well with IPv6)
- Constructed from MAC address (also works well with IPv6)
- Address pool/subdivision (likewise!)
- Problem: network partition/remerge

Summary

- IPv6 enables stable, long-term addressability
  - This is important for identifiers, thus for mobility
  - Even more so for ad hoc nodes needing to obtain addresses
- IPv6 is ready to roll out now
- We “have to” do it eventually anyway
  - Maybe the users (the real Internet) will never know
  - But people are still driving Hummers, oops, oh well...
- Mobile IPv6 offers scalable new authentication
  - Revolutionary? Can we derive further benefits?
- NATs deterioriate wireless nodes and services
  - NATs damage the ability to have stable addresses
  - Ad hoc *unworkable* with overlapping IP addresses