The Impact of IPv6 on Semantic Interoperability

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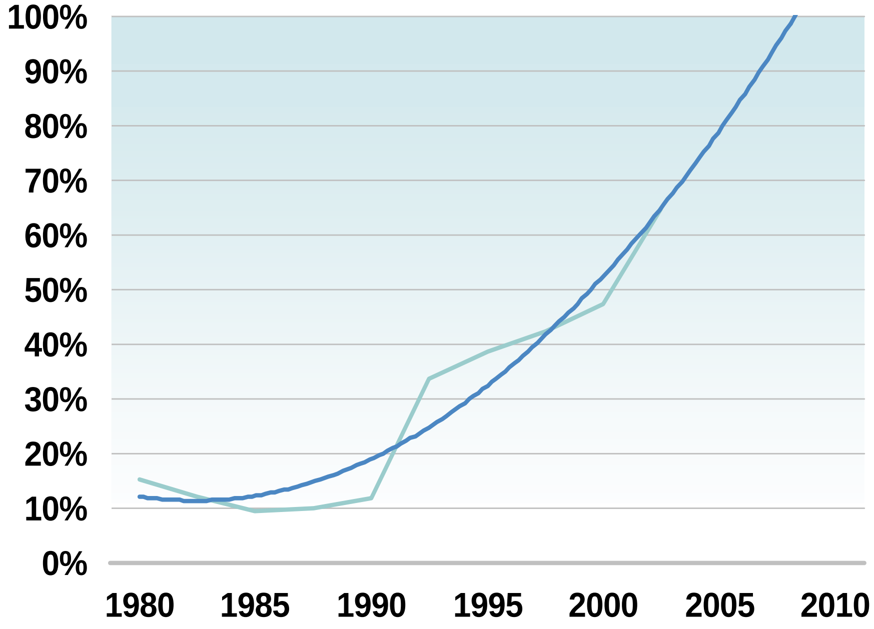
Agenda

- Emergence of IPv6
- Features of IPv6
- IPv6 Addressing
- RFID Overview
- IPv6 and RFID Integration

Emergence of IPv6

IPv4 Address Allocation History

- **1981 – IPv4 protocol published**
  - **IP addresses used to uniquely identify and locate IP devices**
- **1985 – 1/16 of total space**
- **1990 – 1/8 of total space**
- **1995 – 1/3 of total space**
- **2000 – 1/2 of total space**
- **2002.5 – 2/3 of total space**



- **This consumption despite increasingly intense conservation efforts**
  - **PPP/DHCP address sharing**
  - **NAT (network address translation)**
  - **CIDR (classless interdomain routing) plus some address reclamation**

Do We Really Need IPv6?

- **In the early 1990s, the IETF IPv6 WG began to solve addressing growth issues**

  But CIDR, NAT, … were developed

- **IPv4 32-bit address = 4.2 billion hosts (2^{32})**

  But practical limitation (defined by RFC 3194) constrains the public address space to a few hundred million (<1/10th the mathematical possibility)

  The increase of Internet-connected devices and appliances will eventually deplete the IPv4 address space

- **So, the only compelling reason: More IP addresses!**

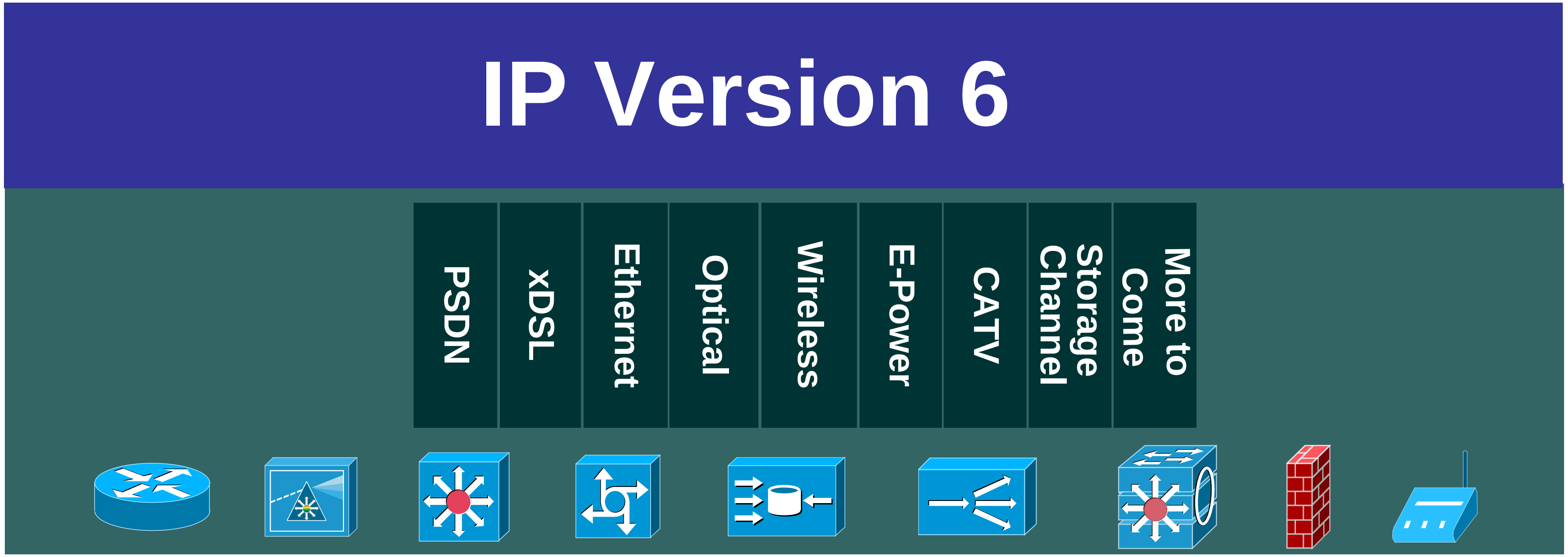
Who/What Uses IP Addresses?

- **Internet population**
  - End of 2004 = ~945M – only 10–15% of the global population
  - How can we address the future Worldwide population? (~9B in 2050)
  - Emerging Internet countries need address space
- **Mobile Internet introduces a new generation of Internet devices – no wires!**
  - PDAs (~20M in 2004)
  - Mobile phones (~1.5B in 2003)
  - Tablet PCs

- **Transportation – mobile networks**
  - 1B automobiles forecast for 2008 – begin now on vertical markets
  - Internet access on planes (Lufthansa) and trains (Narita express)
- **Consumer, home and industrial appliances**

IP: The Application's Convergence

With Billions of New Devices Becoming IP-Aware, the Need for Increased Addressing and Plug-and-Play Networking Is Only Met with the Deployment of IPv6

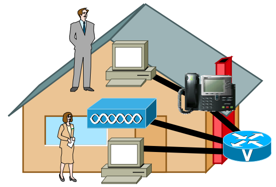


Drivers for IPv6

IPv6 Activity

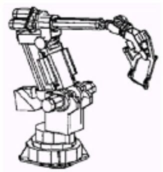
Higher Education/ Research

- Media services
- Collaboration
- Mobility



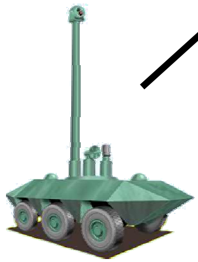
Consumer

- Set-top boxes
- Gaming
- Appliances
- Voice/video
- Security monitoring



Manufacturing

- Embedded devices
- Industrial Ethernet
- IP-enabled components



Government (Federal/Public Sector)

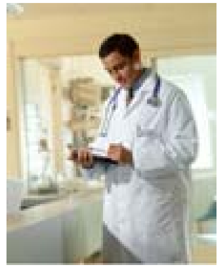
- DoD
- WIN-T
- FCS
- JTRS
- GIG-BE

Transportation

- Telematics
- Traffic control
- Hotspots
- Transit services

Agriculture/ Wildlife

- Animal tags
- Imagery
- Botanical
- Weather



Medical

- Home care
- Imaging
- Mobility

Features of IPv6

A Few Advantages of IPv6

- **Scalability**
  - Massive address space eliminates the need for NAT/PAT
  - Address translation has proven to be costly and a deterring factor in the deployment of new applications
  - Eases network expansion, reduction, mergers and acquisitions
- **Ease of Deployment**
  - Stateless Autoconfiguration, DHCPv6 and Router Renumbering
- **Security**
  - Mandated IPsec in the protocol
  - Privacy Extensions

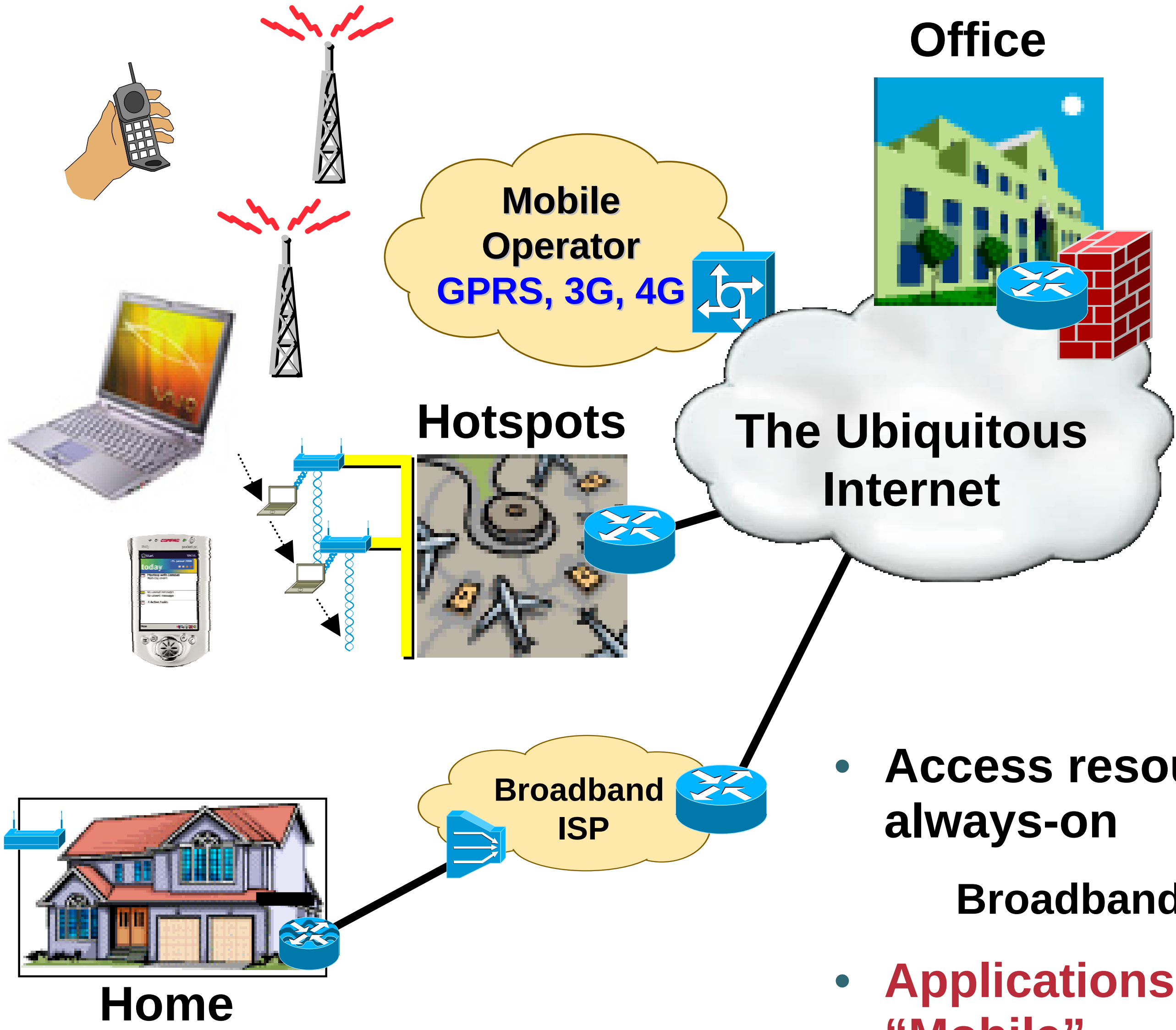
- **Mobility**
  - Always-on global accessibility without existing Mobile routing complexity
  - Mandated IPsec

- **Multicast/Anycast**
  - Address capabilities all for distributed applications to work without address constraints or re-use
  - Route to "nearest" service

IPv6 Security

- **RFC “mandates” privacy and encryption**
- **Same IPSec already in use**
- **Two security extension headers defined; all implementations required to support (IPSec)**
  - **Authentication Header (AH)**
  - **Encapsulating Security Payload (ESP)**
  - **Key distribution protocols are under development**
  - **Support for manual key configuration required**
- **New concept of “Privacy Extensions”**
  - **On by default in Microsoft XP SP1+**
  - **Randomly generated address used as the source address for applications**
- **Nearly impossible to perform successful network scans**

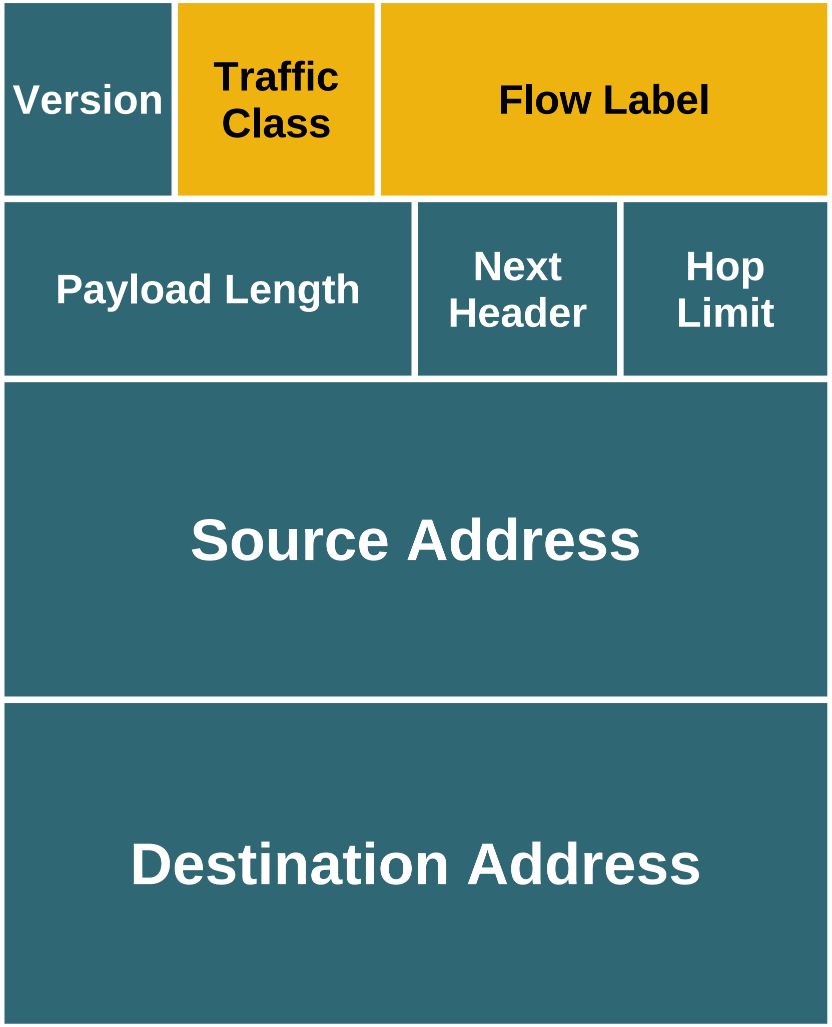
IPv6 Mobility Vision



- Independent from the Access Technologies
- Unlicensed Band (WiFi, ...)
  - Personal Mobility
  - High data rate incremental infrastructure
- Licensed Band (GPRS, 3G, WiMax, DVB-T, …)
  - Full mobility
  - New infrastructure
- Access resources from anywhere – always-on
  - Broadband/Wireless services Convergence
- Applications and Services have to become "Mobile"

IPv6 Quality of Service (QoS)

- **IPv6 QoS – Same architectural models as IPv4**
  - Differentiated Services (Traffic Class field)
  - Integrated Services (RSVP)
- **IPv6 Traffic Class**
  - Value defined per applications, same DSCP for applications over both IPv4 and IPv6 – decision to differentiate per protocol is an operational one
- **RSVP for IPv6**
  - Major RSVP RFCs do support IPv6
  - Use Hop-by-Hop option header for Router Alert
- **IPv6 Flow Label (RFC 3697)**
  - A new 20-bit field in the IPv6 basic header
  - Its value cannot be changed by intermediate devices
  - No RFC regarding flow label usage yet
- **Transition**
  - Mapping between IPv6 DSCP & IPv4 ToS or MPLS EXP



IPv6 Addressing

From 32 (IPv4) to 128 (IPv6) Bits

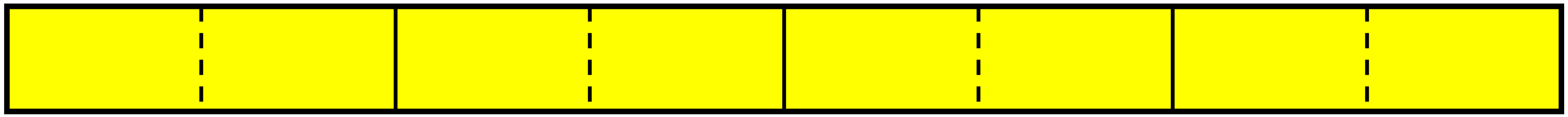
- **IPv4 uses 32 bits of address space**

  ~4.2 billion possible addresses

- **IPv6 uses 128 bits of address space**

  ~340 undecillion possible addresses

  = 340,282,366,920,938,463,463,374,607,431,768,211,456 (for those not familiar with the "-illion" scale)

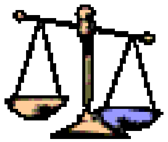


128 = 340,282,366,920,938,463,463,374,607,431,768,211,456

What 128 Bits Mean

$$\frac{2^{128}}{6.5\ \text{billion}}$$ = ~52 octillion IPv6 addresses per person (52,351,133,372,452,071,302,057,631,912)

The Earth's population is ~6.5 billion



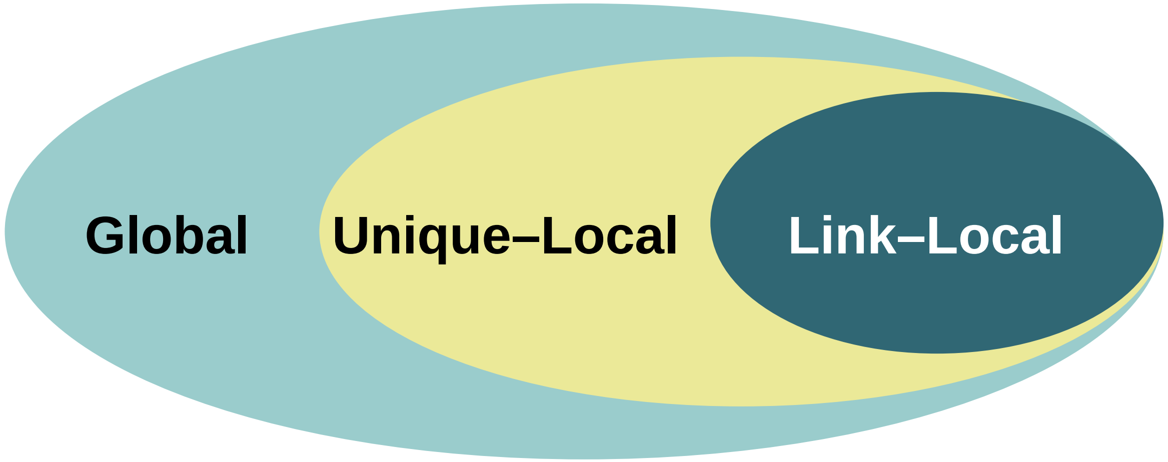
If each IP address weighed one gram, the IPv6 address space would weigh more than 56 planet Earths

$$\frac{52\ \text{octillion}}{100\ \text{billion}}$$ = ~523 quadrillion IPv6 addresses per brain cell (523,511,333,724,520,713)

A typical brain has ~100 billion brain cells (your mileage may vary)

Addressing Model

- **Addresses are assigned to interfaces**
  - **Change from IPv4 model**
- **An interface is "expected" to have multiple addresses**
- **Addresses have scope**
  - **Link local (FE80::/10)**
  - **Unique local (FC00::/7)**
  - **Global (2000::/3)**
  - **Documentation (2001:DB8::/16)**



- **Addresses have lifetime**
  - **Valid and preferred lifetime**

Individual IPv6 Addresses

- **Hex is in**  **… dotted-decimal is out** 

  8 groups of 16-bit hexadecimal numbers (4 digits each) separated by (:)

  Hex numbers are not case sensitive

  Leading zeros can be suppressed

  A contiguous block of zeros could be represented by (::)

  Example of reducing an IPv6 address:

2003:<u>0000</u>:130F:<u>0000</u>:<u>0000</u>:<u>087C</u>:876B:140B

2003:0:130F:0:0:87C:876B:140B

2003:0:130F::87C:876B:140B

(Double colon may only appear once in the address)

IPv6 Address Representation

- **Prefix Representation**

  Representation of prefix is just like CIDR

  In this representation you attach the prefix length (‘slash’ notation)

  Examples:

  IPv4 address: 198.10.0.0/16

  IPv6 address: 2001:db8:1200::/40

- **Address Representation**

  Includes both the prefix and host portions

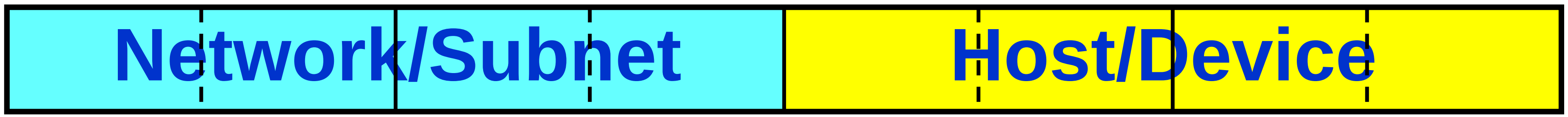
  Examples:

  IPv4 address: 198.10.1.1/24

  IPv6 address: 2001:db8:1200:37f8::5ba3:8431:3c:103/64

IPv6 Subnets and Hosts

- **The smallest typical IPv6 subnet is a /64**
  - **/64 means 64 bits in the network portion of the IP address**
  - **This leaves 64 bits in the host portion of the address**
- **64 host bits means that there can be ~18 quintillion devices on one subnet**
  - **18,446,744,073,709,551,616 unique addresses per subnet**
  - **In a “normal” IP network, this is absolutely ludicrous**
  - **But what if you only need to uniquely identify objects?**



RFID Overview

RFID Technology

- **An RFID tag is a transponder**
  - It is a microchip that can receive and respond to RF queries from an RFID transceiver
  - A smart bar code
- **Components includes tags, readers, servers and processing software**
- **Tags can be active or passive**
  - Passive ones are very small since there is no battery
  - Active ones are larger due to the internal power source
- **Operate on multiple frequencies and provide different reading ranges**

RFID Today - It's All Around Us

- **EZ-Pass System**
  - Toll collection system up and down the east coast
  - Card stores a unique ID
  - Central server is notified when the card is used at toll plazas
- **SmarTrip Cards**
  - Parking and Metro access in Washington, DC
  - Rechargeable card stores monetary value and tracks subway entry/exit
  - Card is debited as you enter a bus, exit the subway or leave a parking structure
- **Exxon-Mobil SpeedPass**
  - Encrypted communication between the wand (card) and the reader
  - Similar to EZ Pass card – card stores ID, central server stores data

RFID Applications

- Children safety
- Hazard area monitoring
- Inventory tracking / supply chain
- Environmental monitoring
- Barcode replacement
- Patient identity / medical records
- Equipment location

RFID Tag Representation

- **The Electronic Product Code (EPC) Global Network**

  Each RFID tag has a mandatory unique identity

- **EPC Numbering Scheme – 96-bit tag**

  Header (Version #) → 8 bits

  EPC Manager (Manufacturer/Enterprise) → 28 bits

  ~268M enterprises

  Object Class (SKU) → 24 bits

  ~16.7M classes

  Serial Number (Unique ID for each item) – 36 bits

  ~68.7B serial numbers

H	EPC Manager	Object Class	Serial Number

IPv6 and RFID Integration

IPV6 and RFID Integration Facts

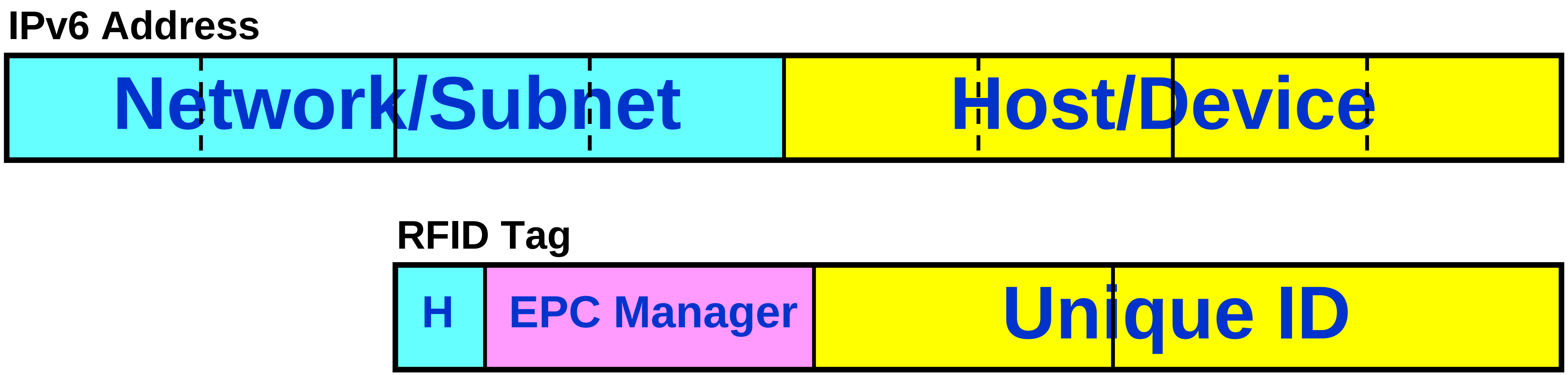
- **IPv6**
  - **IPv6 addresses are 128 bits in length**
  - **The first 64 bits are the subnet portion**
    - **This is how routers determine location**
  - **The last 64 bits are the interface ID portion**
    - **This uniquely identifies a device on a subnet**
    - **64-bits = ~18 quintillion unique devices**
- **RFID**
  - **Tags are 96 bits in length**
  - **Company-specific data (unique identity) is 60 bits**
    - **a 28 bit object class and a 32 bit serial number**
    - **only ~1.1 quintillion unique identities available ☺**

Integration Mapping

- A single IPv6 subnet maps the entire RFID space for a company
  - That subnet would be a 'wireless' subnet that stretches *wherever*
- Each RFID tag becomes addressable in the IPv6 network
  - The reachability scope is defined by the IPv6 prefix used
- Location computation software could directly communicate with tagged devices from anywhere within the IPv6 network

The Integrated Address

- The RFID Object Class and Serial Number become the IPv6 Interface ID
- The local router assigns one or (likely) more IPv6 prefixes for local, site, global, and multicast reachability



Conclusion

- **IPv6 and RFID appear to 'play well' together**
  - The address formats fit nicely together
  - No conflicts, no loss of functionality
- **An IP address on an RFID device makes the object reachable**
  - Additional capabilities would require implementation of an entire network stack
- **RFIDs/IPv6 addresses can be triangulated to determine location**

Q and A

Thank You!

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