Hasso Plattner Institut

IT Systems Engineering | Universität Potsdam

Challenges of IPv6: Security and New Applications

Seminar for Master of IT System Engineering (WS2010/2011)

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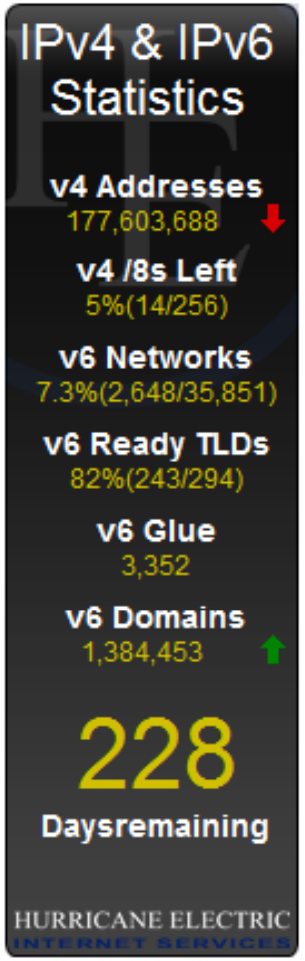
Outline

- Motivation
- Quick overview of IPv6
- Seminar topics
- Organization
- Evaluation

Motivation

Motivation (1)

- 2^{32} total addresses **-> 4 billion**
- IPv4 addresses are not enough for all new devices
  - Laptops, mobiles, GPS, other online devices
- IPv4 is full, only **5%** of IPv4 are left
- IPv4 probably will run out before **2012**
  - IANA pool depletion date: 170 days (08.04.2011)
- NAT is a temporary solution
  - NAT breaks end-to-end network
- IPv6 is the next generation Internet protocol



Motivation(2)

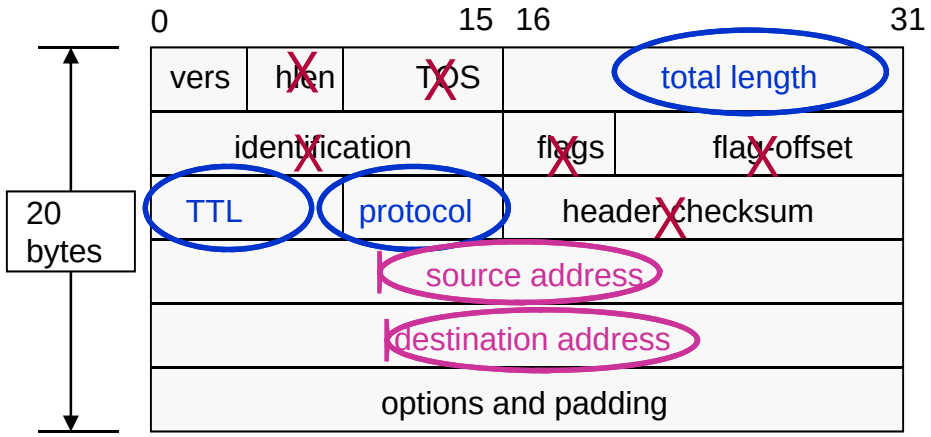
- IPv6 means Internet and **business continuity**
  - Everything on the Internet over IP
- **You have to be ready**
  - IPv6 is widely available and it is enabled by default in many systems
  - IPv6 is expected increasingly deployed in the coming few years
- IPv6 comes with new features
  - Security
  - Autoconfiguration
  - Extensibility
  - …
- IPv6 will coexist with IPv4 for long time
- **This seminar** will discuss both challenges of:
  - IPv6 security issues
  - IPv6 new applications

Quick overview of IPv6

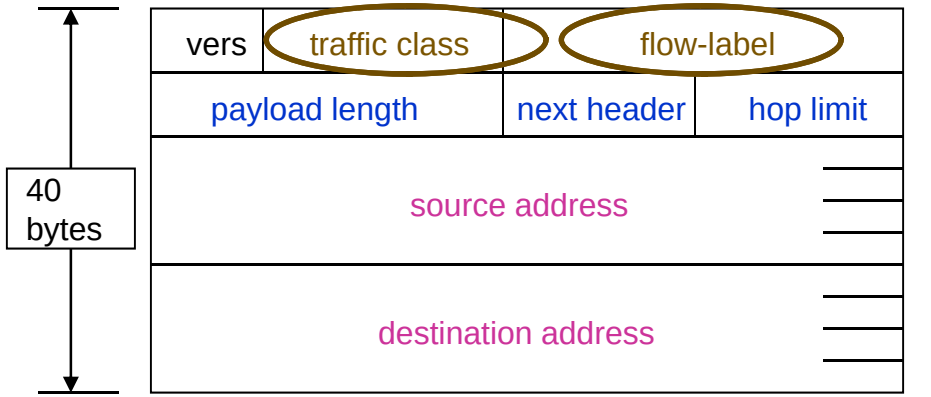
IPv4 & IPv6 Comparison (addresses)

	IPv4	IPv6
Address Size	32-bit number	128-bit number
Number of Addresses	2^{32} = 4,294,967,296 = **4 billion** addresses	2^{128} = 340,282,366,920, 938,463,463,374,607,431, 768,211,456 =**340 trillion trillion trillion** addresses
Address Format	Decimal notation: 192.146.200.67	Hexadecimal notation: 2001:5Feb:Beef::Cafe
Prefix Notation	192.146.0.0/**24**	2001:5Feb:Beef::/**48**

IPv4 & IPv6 comparison (headers)



IPv4



IPv6

Removed (6)

- hlen, TOS
- ID, flags, flag offset
- header checksum

Changed (3)

- total length => payload
- protocol => next header
- TTL => hop limit

Added (2)

- traffic class
- flow label

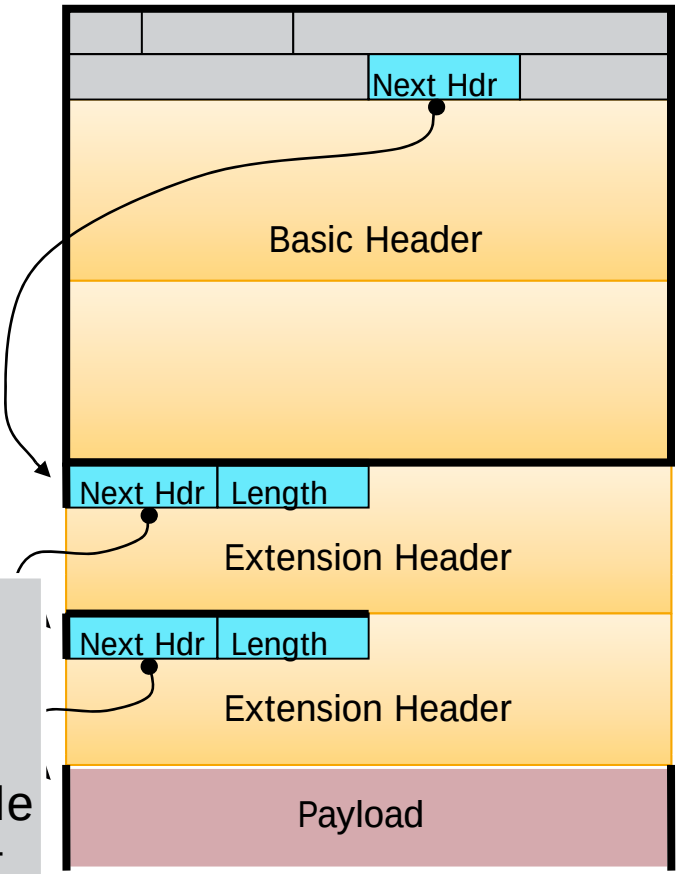
Expanded

- address 32 to 128 bits

Extension headers

- Extension Header Types
  - Routing Header
  - Fragmentation Header
  - Hop-by-Hop Options Header
  - Destinations Options Header
  - Authentication Header
  - Encrypted Security Payload Header

IPSec



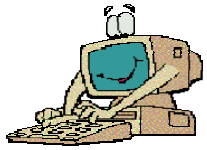
Security concerns:

- Manipulate a malicious packet is possible
- Header chain can make filtering difficult

Address configuration

Three ways of configuration:

1. Manual (Least preferred, but possible)
2. DHCPv6 → required a Server
3. **Stateless Autoconfiguration**



Prefix	Interface Identifier

IPv6 Address

Prefix can be

- Link-Local address (FE80::/64)
- Global Unicast address
  - Routers send periodic Router Advertisement (**RA**) which contains link prefix, lifetime, MTU, etc.
  - Host may also send router solicitation (**RS**) to get trigger RA

The interface ID generated by

- EUI-64→ Formed from MAC address of interface
- Randomly generated → Provides some level of privacy
- Cryptographically Generated Addresses (CGA)
- Possible other methods in the future

Neighbor Discovery Protocol (NDP)

- **Neighbor discovery Protocol functions:**
  - Discover the presence and MAC addresses on the same link
  - Duplicate address detection
  - Discover routers
  - Detect when a local node become unreachable

- **Some of NDP messages**
  - ICMPv6 router solicitation (RS)
  - ICMPv6 router advertisement(RA)
  - ICMPv6 neighbor solicitation(NS)
  - ICMPv6 neighbor advertisement(NA)
  - ICMPv6 redirect

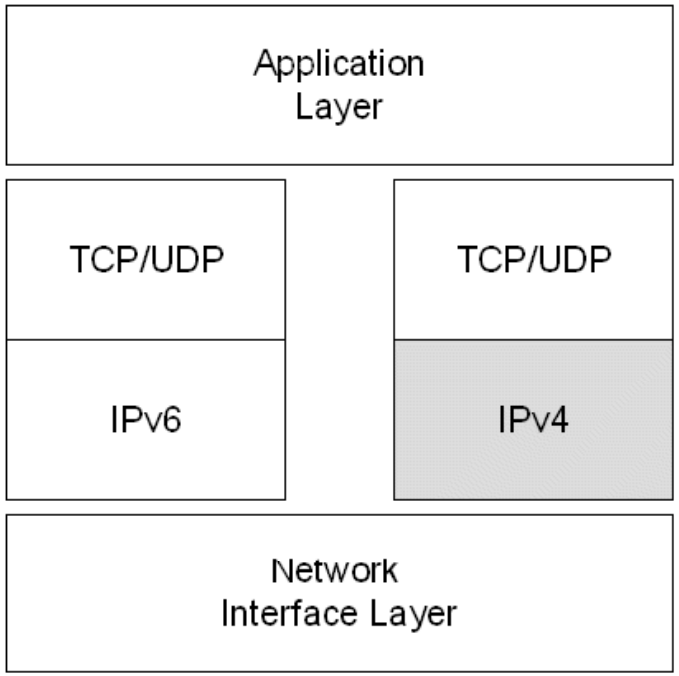
Security concerns:

- NDP has no built-in security → similar to the ARP in IPv4
- Possible attacks against NDP
  - Stealing address
  - DoS attacks
  - Forged router
  - ...

IPv6 and IPv4 Coexistence

- More than 16 methods
- Theses methods can be categorized into 3 types
  - Dual Stack
  - Tunneling
  - Translation: to allow IPv6-only devices to communicate with IPv4-only devices (deprecated by IETF)
- Expect to be used in combination

Dual Stack

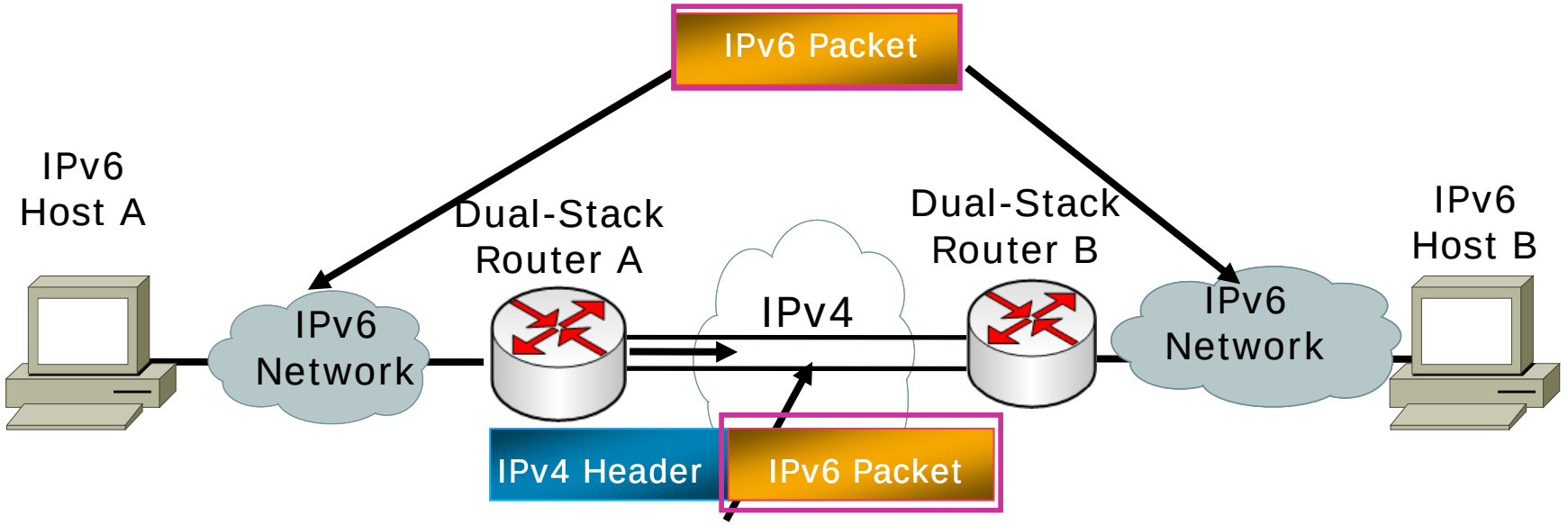


Security concerns:

- Consider the security for both protocols

Allow IPv4 and IPv6 to coexist in the same node

Tunneling

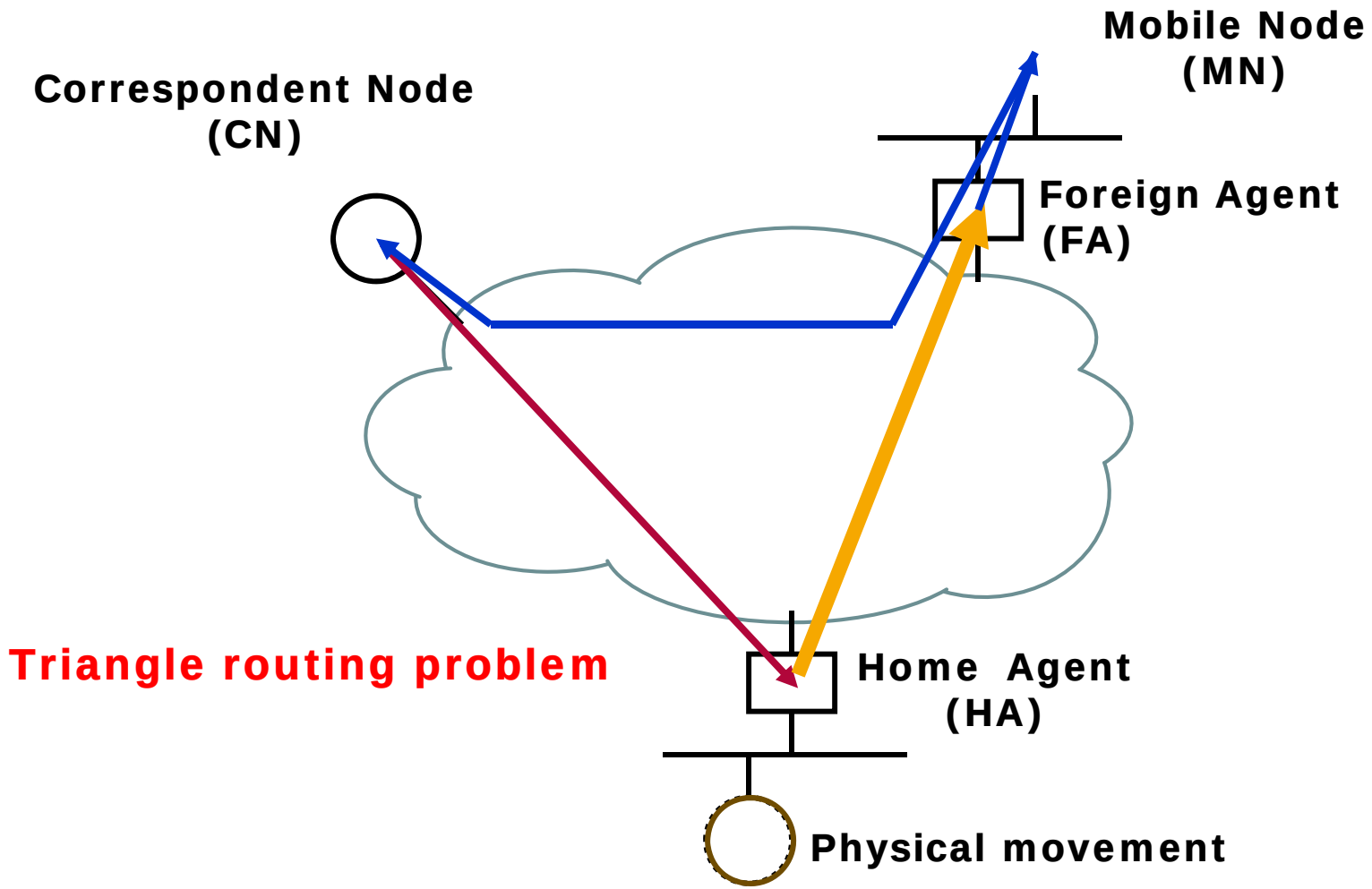


Tunnel: Encapsulating IPv6 in IPv4 Packet

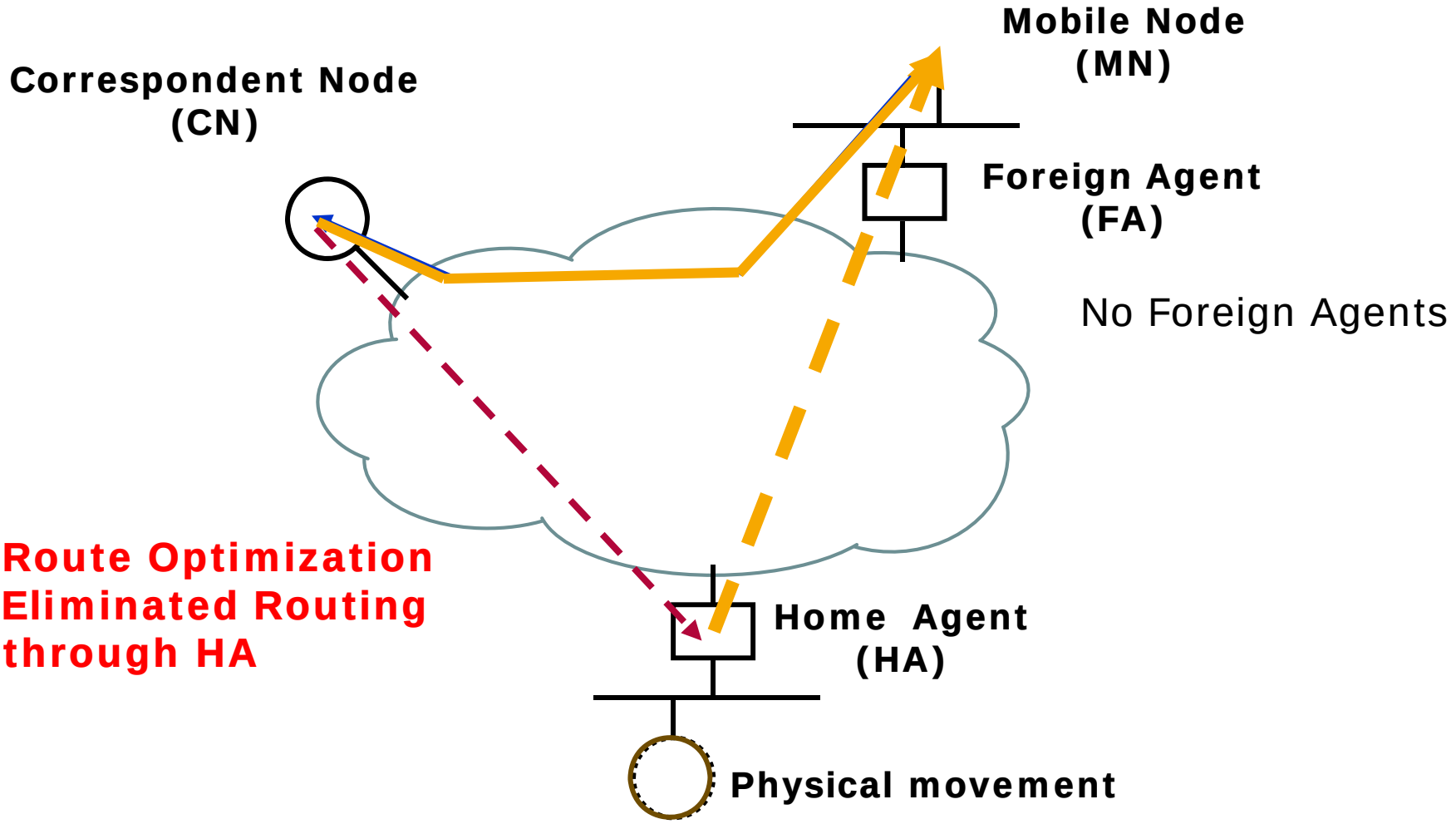
Security concerns:

- Bypass IPv6-unaware firewalls
- Provide a hiding place for DoS attacks

Mobile IP (v4 version)



Mobile IP (v6 version)



IPv6 Security

- Security was considered from the beginning in IPv6
  - IPSec useable with the core IPv6 protocol (**IPSec save the World!**)
  - Cryptographically Generated Addresses (CGA)
  - SEcure Neighbour Discovery (SEND)

Some questions:

- Why IPSec is not widely used in IPv6 network?
- Why SEND is not implemented by some vendors?
- What is the cost of deploying the CGA in limited recourses devices?

Summary of main of IPv6 features

- **Large address space**
  - Facilitating end-to-end services and applications
  - Improving address allocation and managing routing table growth
- **Simplifed header**
  - Faster header processing
- **Autoconfiguration**
  - Reduced network administration costs
- **Built-in security**
  - IPSec → mandate the implement
  - SEND→ SEcure Neighbor Discovery
- **Efficient Mobility**
  - MIPv6: More efficient and robust mechanisms
- **Others**
  - Enhanced QoS, Improved support for options / extensions

Seminar topics

Topics for IPv6 Security (1)

- **IPSec with IPv6**
  - IPSec configurations and implementation considered in IPv6
  - IPSec computationally intensive
  - Denial of Service (DoS) attacks on IPSec

  Proposed task
  - **Implement a DoS attack against IPSec in IPv6 and IPv4 environments and evaluate the effectiveness of such attack.**

  Other possible direction
  - Build a performance test for evaluating IPSec performance in IPv6 environment
  - Design automatic rekeying for Internet Key Exchange (IKE) sessions

Topics for IPv6 Security (2)

- **Cryptographically Generated Addresses (CGA)**
  - Secure IPv6 applications using CGA
  - CGAs generation and verification take a long time to be computed

  Proposed task
  - **Implemented interaction module between the central server (e.g. DHCPv6) to do the computation of CGAs and distributed it to other nodes inside the LAN**

  Other possible direction
  - Implement and interactive module between IPSec and CGAs

Topics for IPv6 Security (3)

- **Neighbor Discovery and Secure Neighbor Discovery (SEND)**
  - If NDP is not secured, it is vulnerabilities to several attacks
  - SEND is proposed to avoid NDP threats
  - SEND is **not** implement in many systems

  Proposed task
  - **Implement misuse detection and prevention to mitigate NDP threats based on IPv6 protocol analysis**

  Other possible direction
  - Security analysis and performance evaluation of SEND

Topics for IPv6 Security (4)

- **IPv6 Firewalls**
  - IPv6 firewalls is not exactly mapped to IPv4 firewalls

  Proposed task

  - **Design and implement successful penetration on IPv6 firewalls by manipulating possible attacks by using the IPv6 extension header or other new property comes with IPv6**

  Other possible direction

  - Build a distributed IPv6 firewalls

Topics for IPv6 Security (5)

- **Threats of IPv6 transition mechanisms: Dual stack, tunneling**
  - Analysis the transition techniques from security point of view
  - Find how these techniques may affect the existing defense mechanisms such as Firewalls, IDS

  Proposed task
  - **Design and implement succesful new attaks based on the IPv6 transition mechanisims**

Other topics for IPv6 Security (6)

- **IPv6 based IDS and IPv6 Anomaly traffic monitoring**
  - IDS design and implementation for IPv6 environment

  Proposed task

  - Building intrusion detection models based on IPv6 protocol analysis and how the IDS works if IPSec is used.
- **Mobile IPv6 Security**
  - Security and privacy issues in mobile IPv6
  - Security evaluation of mobile operating system such as Windows
- ....

Topics for IPv6 Applications

Implement a new application that benifits from the new features comes with IPv6 and it is expected to work better in IPv6 enviroments

- Voice over IPv6
  - compare the QoS on IPv6 networks to IPv4 networks
- IPv6 Peer2Peer
  - P2P communication in IPv4 and IPv6 coexistance
- Multimedia stream in IPv6 networks
- IPv6 in wireless mobile devices (Mobiles, PDAs,..)
- ...

Testing environment

- Based on your topic, you can test your implementation on:
  - Virtual Machines (preferable)
  - Network simulators (Mobile scenarios)
    - OMNeT++
    - NS-3

Organization

Organization

- **3** ECTS Points
- Meeting
  - Location: HPI, Room A-2.2
  - Time: 09:15 – 10:45, Wednesday
- Web page of this seminar
  - http://www.hpi.uni-potsdam.de/meinel/lehre/lectures_classes/challenges_of_ipv6_ws201011.html
- Prerequisites
  - A good knowledge of networking concepts is assumed
  - Experience with IPv4 management is expected
- Registration
  - Send an email with your favorite **topic (Ahmad AlSa'deh)** before **27.10.2010**
  - The number is limited to **10**. First send, first get in the seminar.
  - You will receive a notification by replying to your email on **28.10.2010**

Organization

What you have to do?

- Attendance
  - You should show up in all sessions
  - Discussion and challenging questions are highly encouraged
- Select a Topic
  - Investigation, survey
- Give a Talk about your topic and your plan for implementation
  - In English
  - 25 minutes: Presentation
  - 10 minutes: discussion and comments
- Write a Report
  - In English
  - Around 8-10 pages, Springer LNCS

Organization

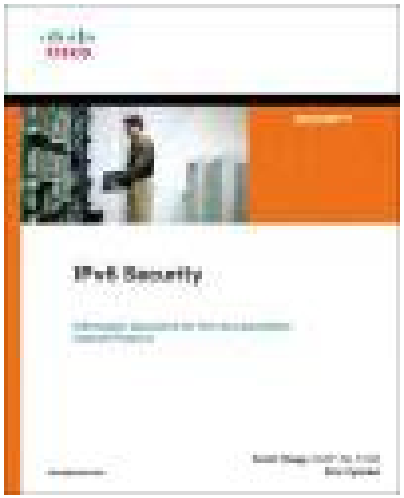
- Evaluation. Your final grade will be based on
  - Talk 20%
  - Participation in the seminar 10%
  - Implementation and testing 30%
  - Final report 40%

Important dates

20.10.2010	**Introduction**
27.10.2010	********
03.11.2010	**Phase 0**: Assign the topics, making the groups
10.11.2010	********
17.11.2011	********
24.11.2010	********
01.12.2010	********
08.12.2010	**Phase 1**: Presentation of the assigned topic
15.12.2010	********
22.12.2010	********
29.12.2010	off
05.01.2011	********
12.01. 2011	********
19.01.2011	********
26.01.2011	********
02.02.2011	**Phase 2:** Showing the practical testing and implementation
09.02.2011	********
16.03.2011	**Phase 3**: submision the final report

Literature

S. Hogg, E. Vyncke, IPv6 Security, Cisco Press, 2009



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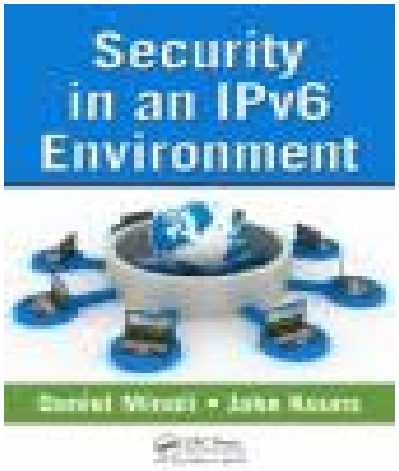

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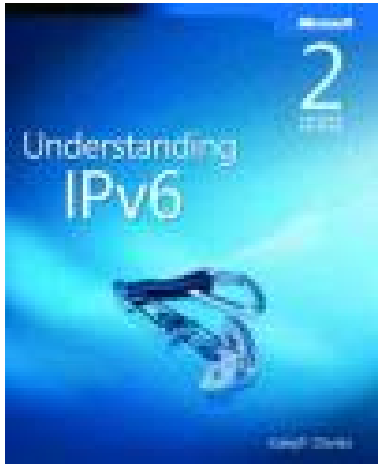

List of other IPv6 Books

http://www.goipv6.se/ipv6books.html

Contact Information

If you have any questions, feel freely to contact us:

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Questions

Seminar topics summary

- IPSec with IPv6
- Cryptographically Generated Addresses (CGA)
- Neighbor Discovery and Secure Neighbor Discovery (SEND)
- IPv6 Firewalls
- Threats of IPv6 transition mechanisms: Dual stack, tunneling
- Implement new applications for IPv6