UNIVERSITY OF TWENTE.

Internet Management and Measurements

Measurements

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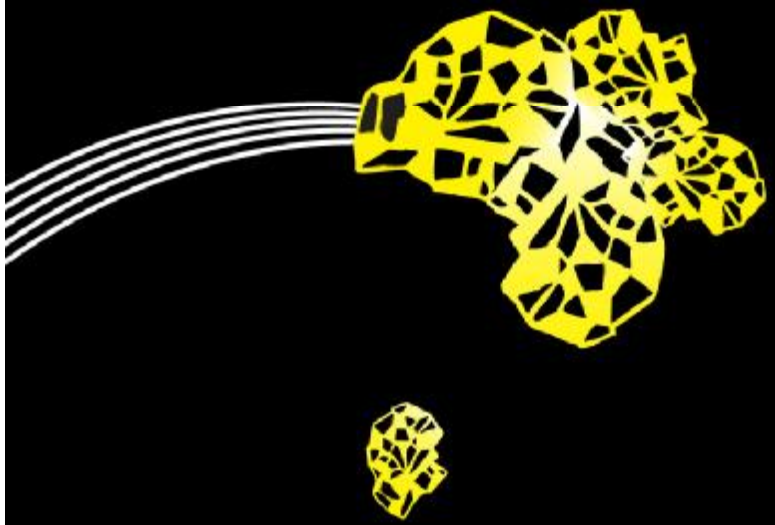

Measurements

- What is being measured?
- Why do you measure?
- How do you do it?

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What is being measured?

- Delay (one-way, round-trip)
- Delay variation (jitter)
- Throughput (average, peak,…)
- Packet loss
- Protocol/application usage
- Nature of data exchanged between hosts
- …

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Why do you measure?

- Traffic engineering
- Intrusion detection
- Accounting
- Lawful interception
- …

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Traffic Engineering

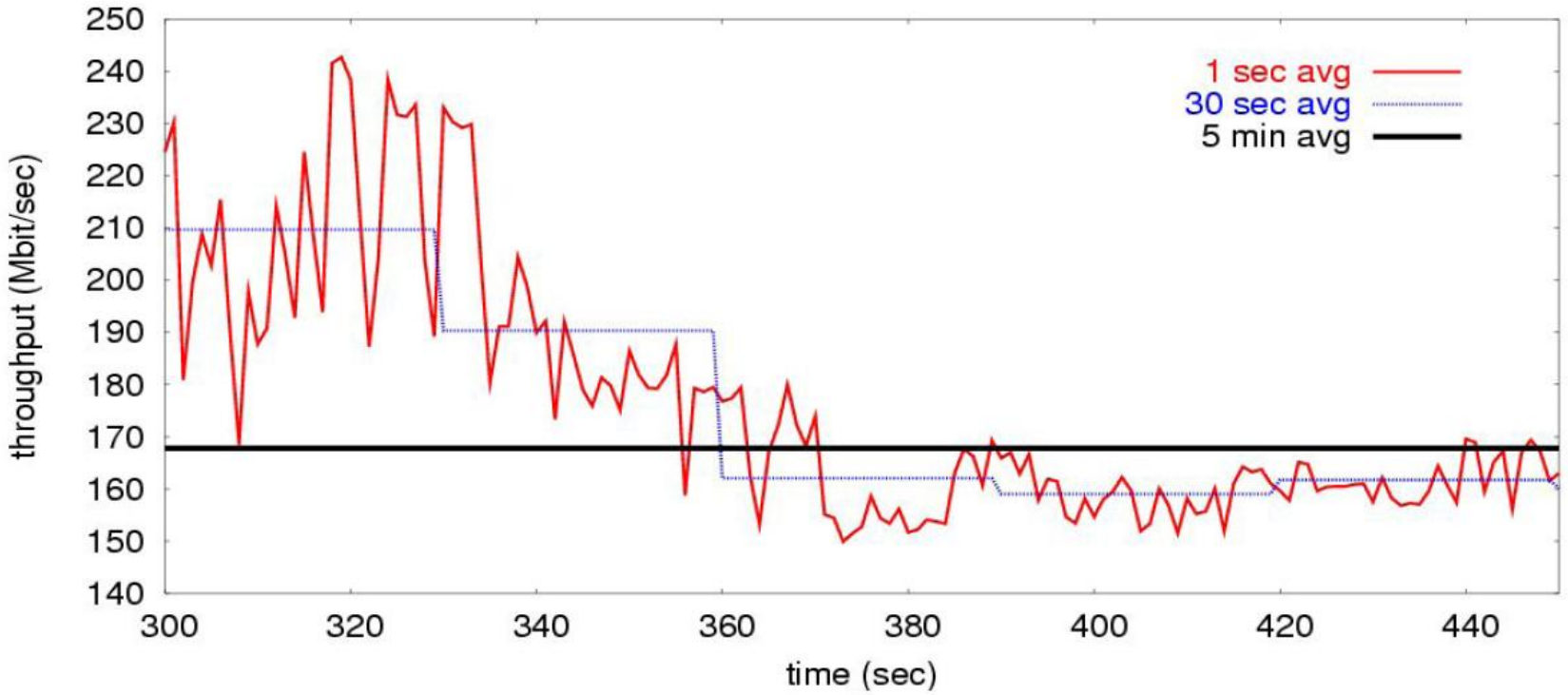
- Predict, plan, understand the behavior of the network
  - Link usage (bottlenecks?)
  - Packet losses
  - Delays
  - …
- Goal: optimize
  - Quality of service provided to customers
  - Costs

Traffic Engineering

- In general, you can not just “try” with the real network
- Needed:
  - Formal models that describe the (future) behavior of the network
  - Tools to evaluate the models by analysis or simulation
  - Measurement data!
    - Create and parametrize the models
    - Validate the results

Example: Dimensioning Router Buffers

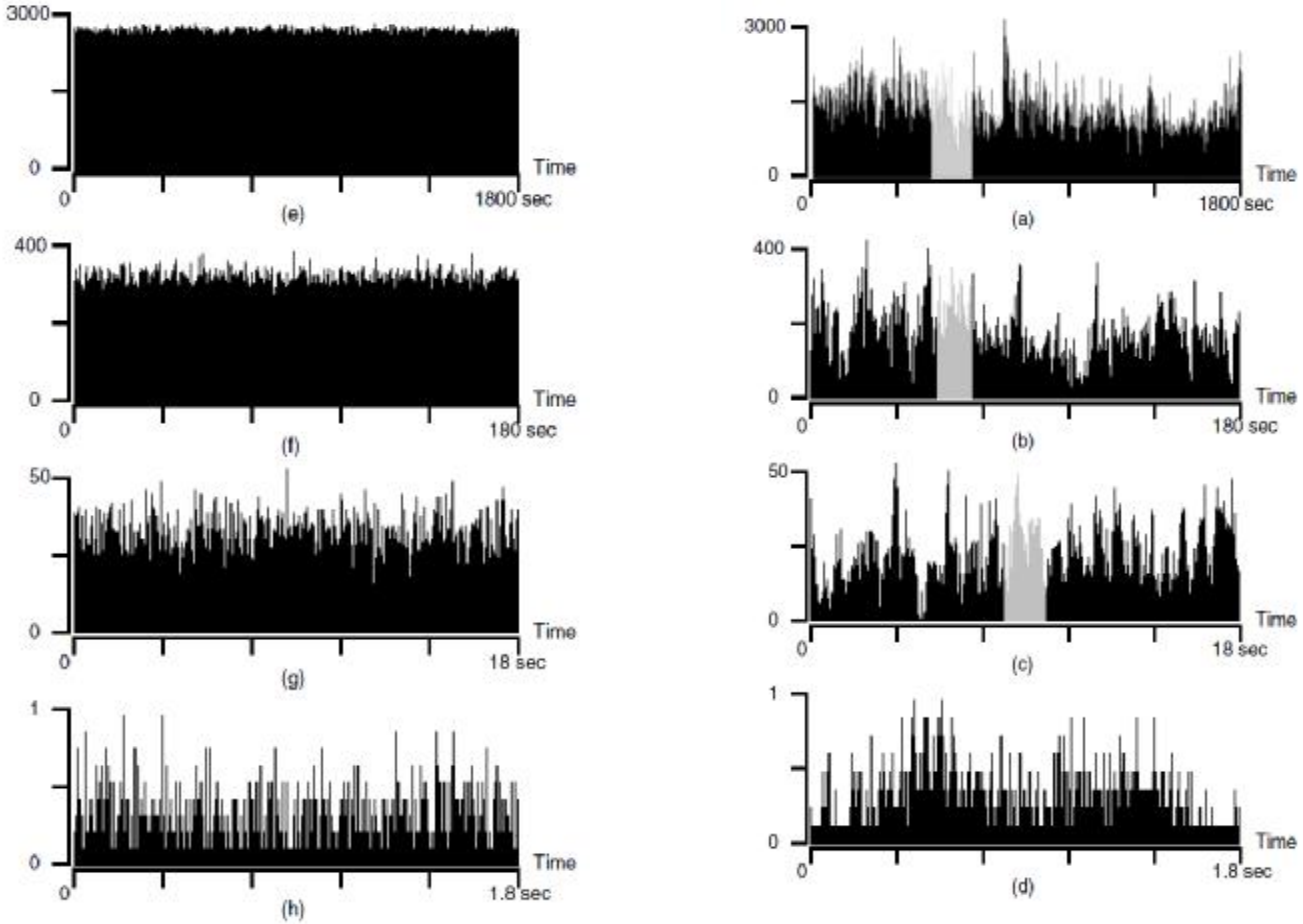
- What is the packet loss L for a buffer size S?
- Router port can be modeled as a queueing station
- Traffic input process?



Modeling Traffic Processes

- What kind of modeling techniques do we need?
- Traditional formal approaches based on “Markovian” behavior (Poisson distributions,…)
- Measurements since the 1980s have shown that network traffic has “non-Markovian” properties:
  - Self-similarity
  - Long-range dependence
  - Heavy-tailed distributions
- Requires new models and tools

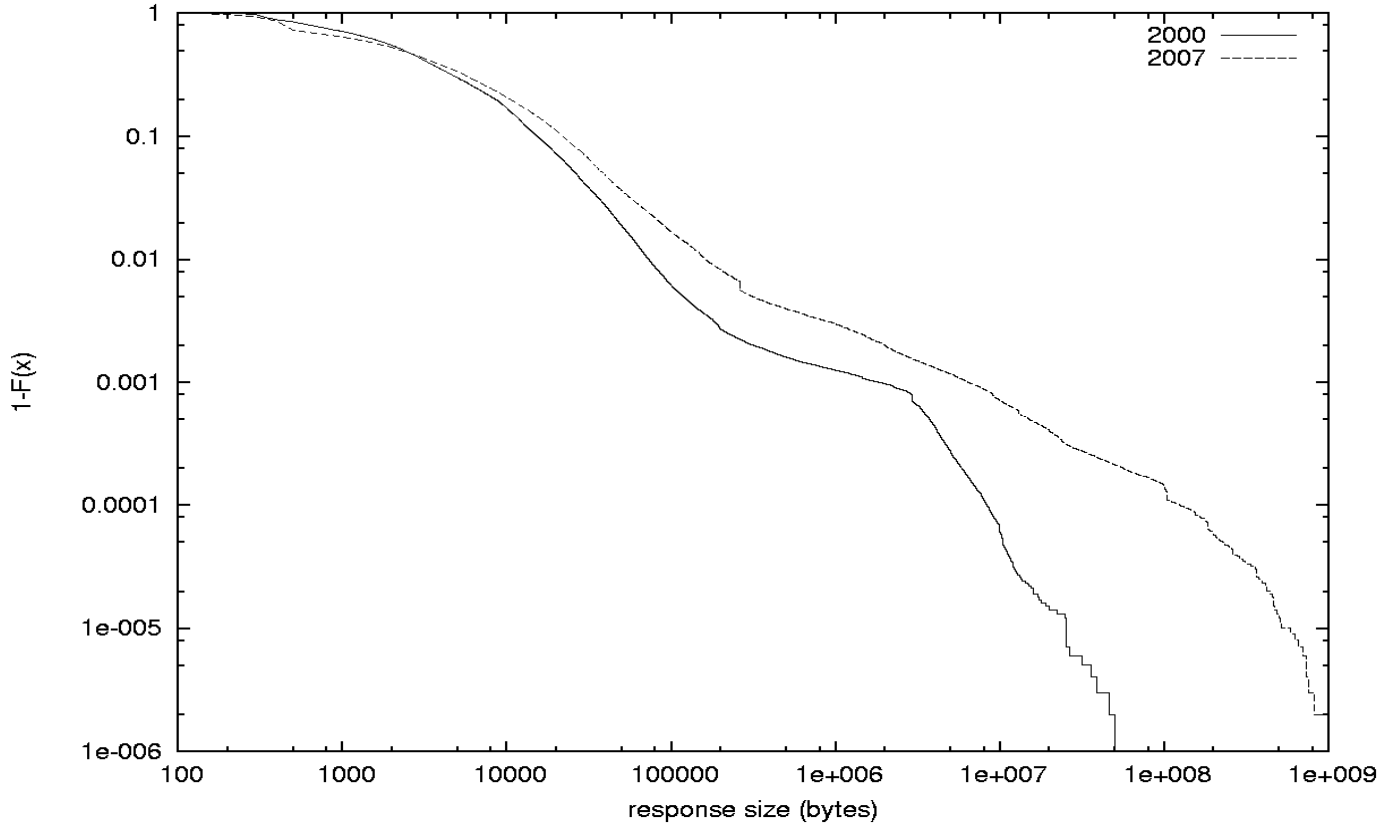
Self-similarity



(from: Traffic Characterisation for Telecommunication Networks, 1999)

Heavy-tailedness

WWW	min	Max	mean	median
2000	17 B	0.23 GB	12 KB	2.4 KB
2007	85 B	2.15 GB	68 KB	2.7 KB



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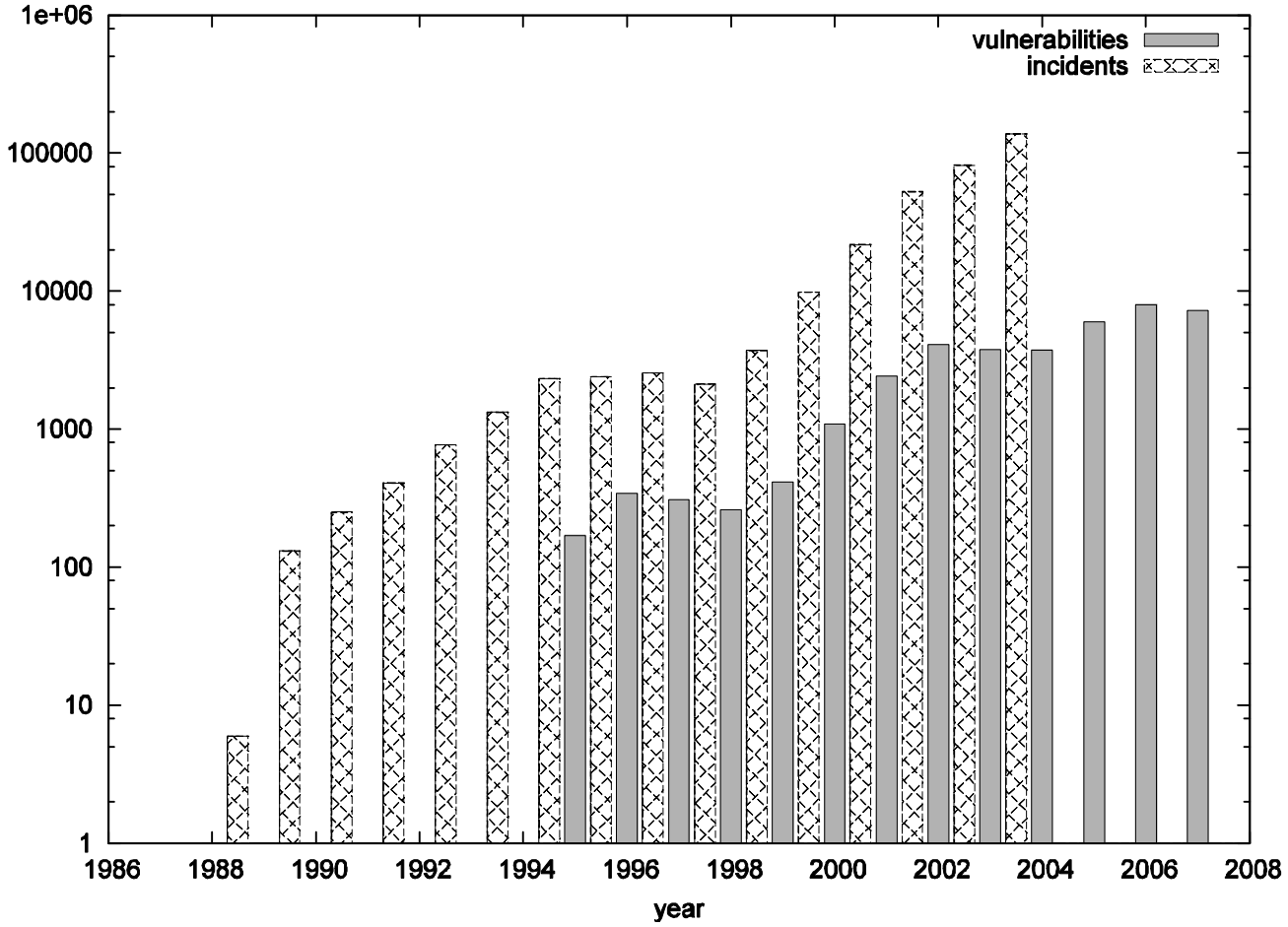
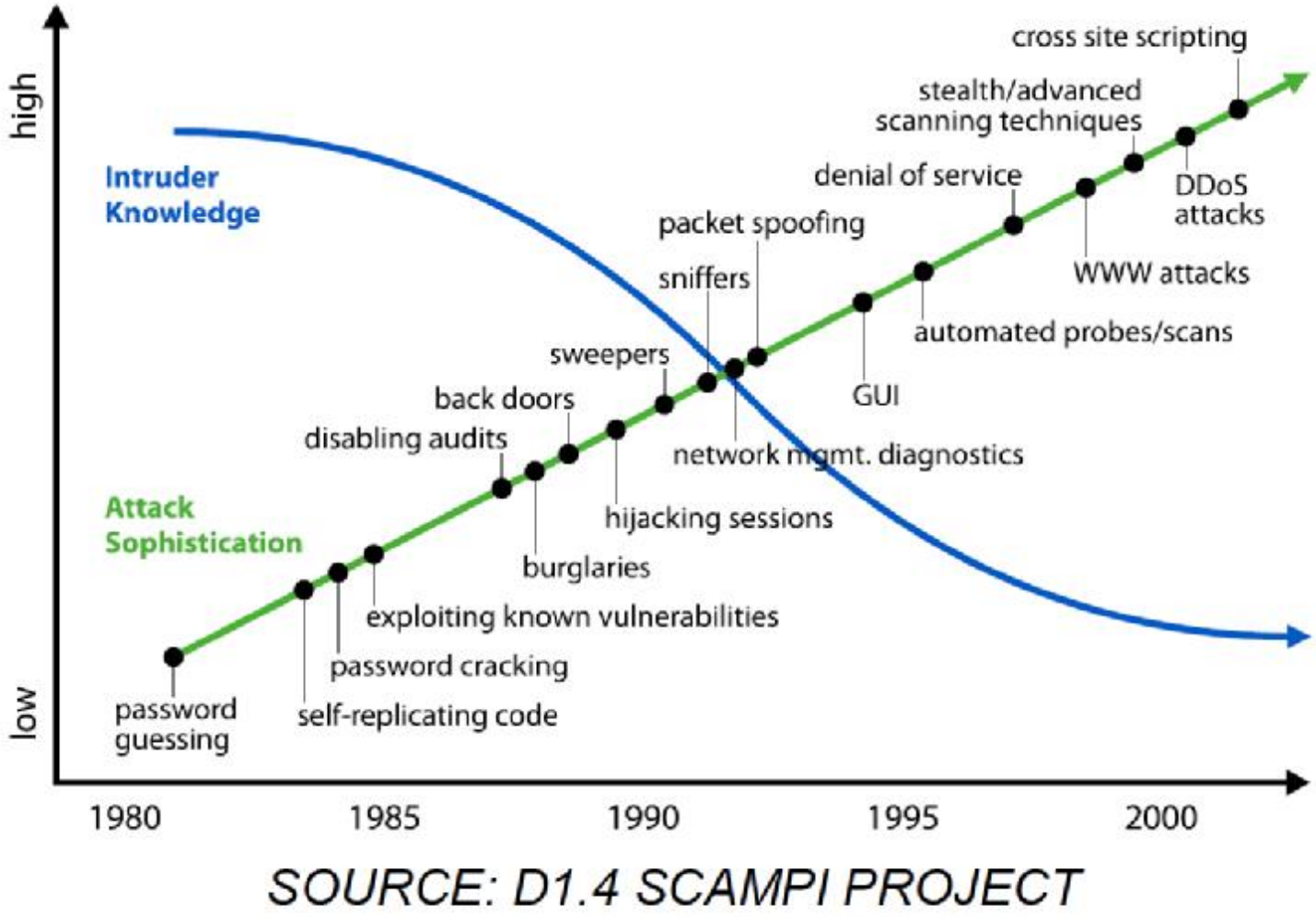
Intrusion Detection

Number of reported incidents (CERT):



Intrusion Detection



SOURCE: D1.4 SCAMPI PROJECT

Intrusion Detection: Classification

Main classification criteria:

- Location of observation
  - Host-based: only observe traffic from/to a particular host
  - Network-based: observe the traffic in a whole (sub)network
- Detection method:
  - Misuse-based: look for known patterns of misuse
  - Anomaly-based: everything that deviates from normality is suspicious

Two reasons to measure:

1. Learn from traffic measurements how good/bad traffic looks like
2. Protect the network

Intrusion Detection: Other Criteria

- Analyzed data:
  - Log files
  - Packet payload
  - Only packet-headers
  - …
- Data collection
  - From multiple locations
  - Only one location
- Adaptation
  - Static: has to be configured by user
  - Self-adapting: adapts automatically to changes in the network
- ...

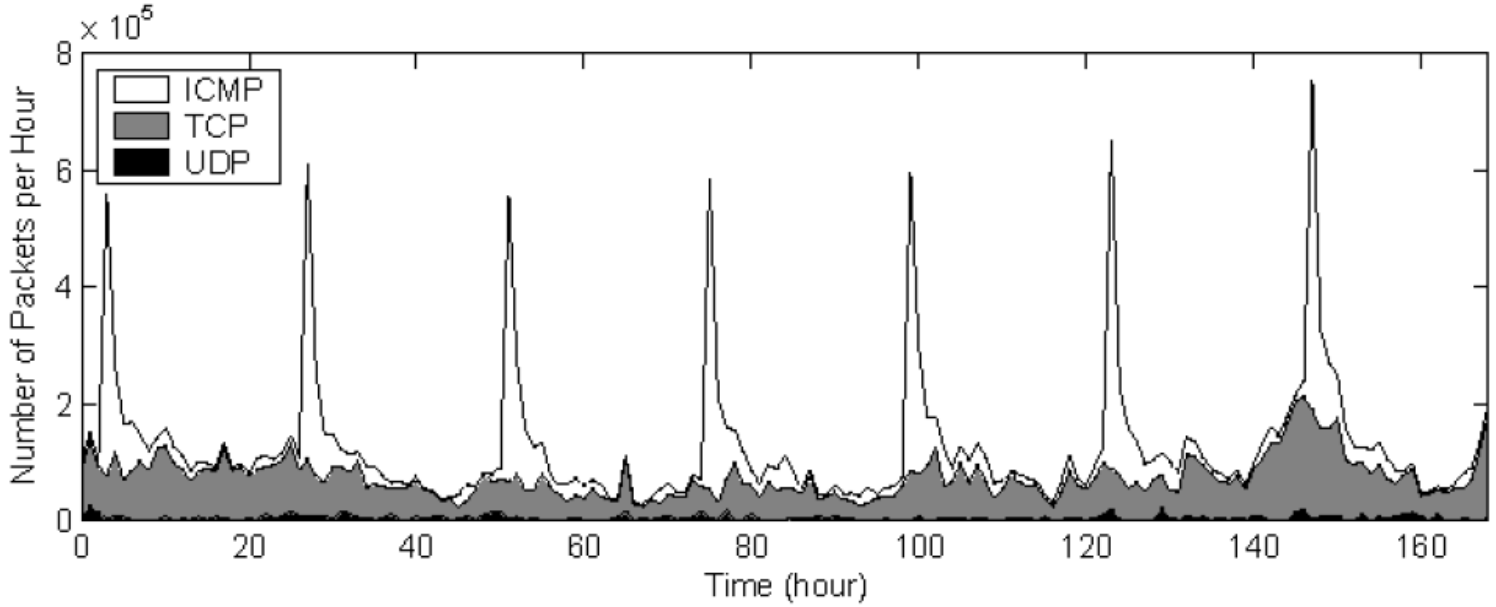
Internet Background Radiation

- Idea: measure all traffic destined for unused IP addresses in a network
- Study at Lawrence Berkeley National Laboratory

  Characteristics of Internet Background Radiation. R. Pang, V. Yegneswaran, P. Barford, V. Paxson, L. Peterson. Proc. of the ACM Sigcomm Internet Measurement Conference, Taormina, Sicily, Italy 2004
- "Background radiation" of the Internet consists of:
  - Non-productive traffic (misconfigurations)
  - Malicious traffic (scans, worms,…)

Measurement Results at LBL

TCP Port	# Source IP (%)	# Packets (%)
445	43.40%	19.70%
80	28.70%	7.30%
135	19.10%	30.40%
1025	4.30%	5.80%
2745	3.20%	3.60%



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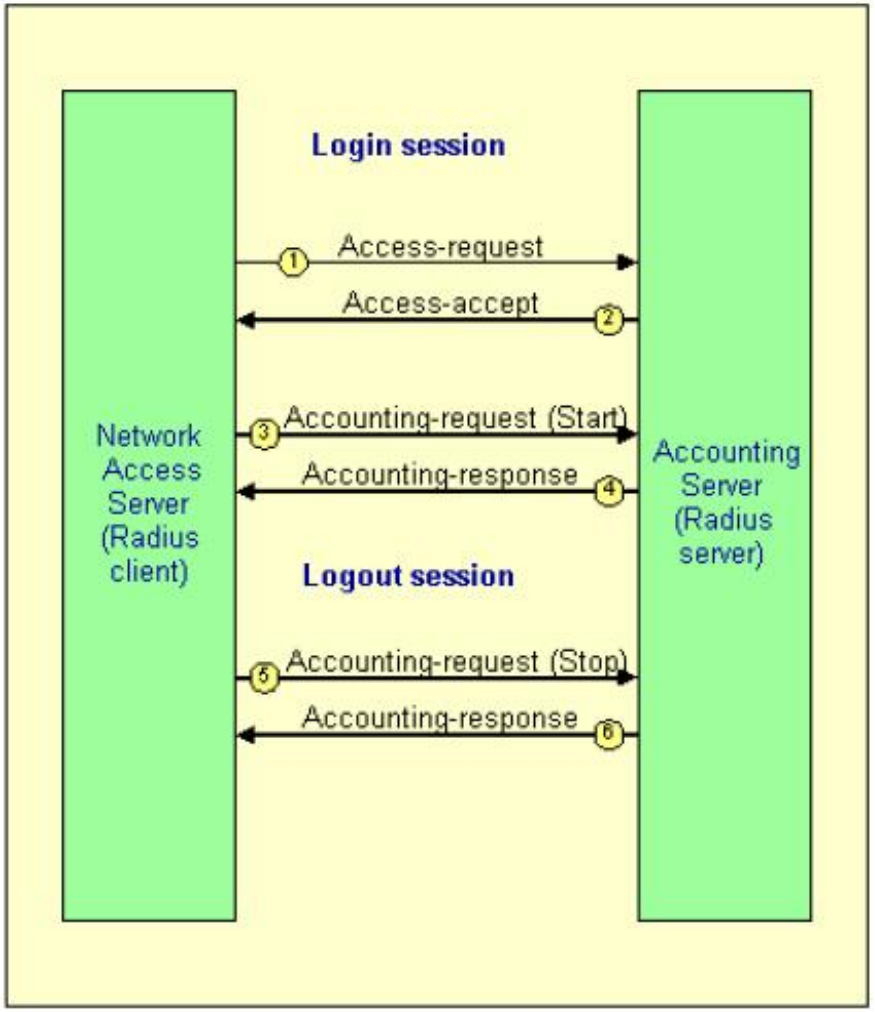
Accounting

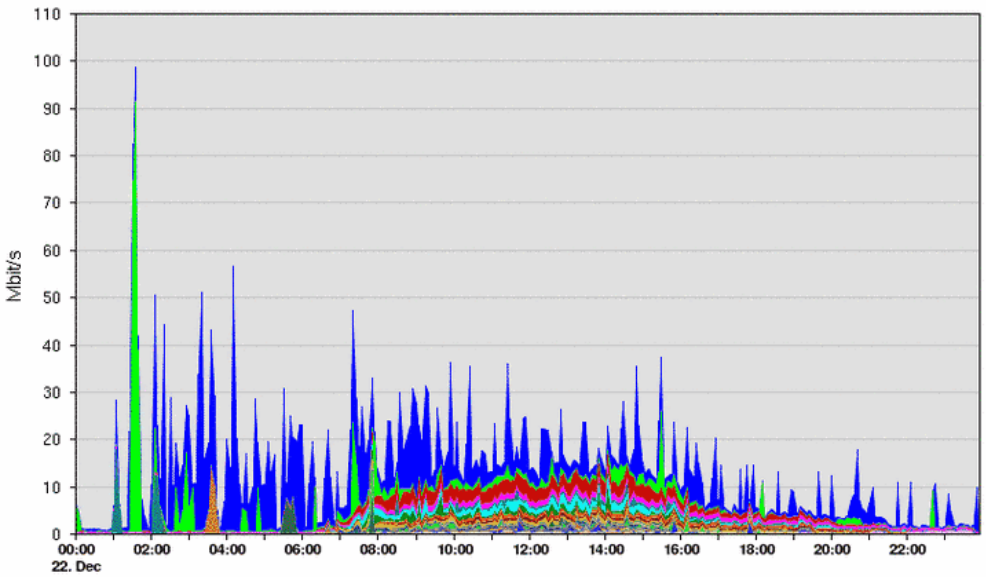
- Who uses what, when, how often?
- Reasons:
  - Billing
  - Limit resource usage
  - Security
- Can be done at different levels:
  - Authentication services
  - Applications
  - Observe the traffic generated by the user
  - …

RADIUS

- RFC 2866
- Logout: NAS sends stop record
  - Session time
  - Packets transfered
  - Octets transfered
  - Disconnect reason
  - …



Traffic-based Accounting: Example IsarFlow (IsarNet, Germany)



Nr.	Protokoll	Byte	min	avg	max	%
1	NETBIOS-SSN (tcp: 139)	70.12 GB	173.30 Kbps	6.97 Mbps	56.27 Mbps	45.94
2	MICROSOFT-DS (tcp: 445)	18.58 GB	26.69 Kbps	1.85 Mbps	91.01 Mbps	12.18
3	HTTP (tcp: 80)	12.13 GB	12.45 Kbps	1.21 Mbps	5.03 Mbps	7.95
4	AUTO: TCP/8000 (tcp: 8000)	6.86 GB	356.84 Kbps	682.43 Kbps	1.25 Mbps	4.50
5	TCP-Other	5.19 GB	7.66 Kbps	516.27 Kbps	18.07 Mbps	3.40
6	HTTP-PROXY (tcp: 8080)	4.71 GB	60.16 bps	468.19 Kbps	2.74 Mbps	3.09

Accounting PerCustomer_RX_TX

Es wurden keine Filter ausgewählt

29.06.2008 00:00 - 23:59

Nr.	Farmname	gesendete Bytes	empfangene Bytes	Bytes gesamt
1	Architektur	18.29 MB	56.32 MB	74.61 MB
2	Betriebswirtschaft	2.17 MB	1.74 MB	3.91 MB
3	Bibliothek	3.13 MB	36.43 MB	39.56 MB
4	Dial-In	69.12 MB	1.04 MB	70.16 MB
5	FH Augsburg (remaining)	4.28 GB	4.96 GB	9.25 GB
6	Gestaltung	9.75 KB	7.76 MB	7.77 MB
7	INTERNET	22.33 GB	21.90 GB	44.23 GB
8	Informatik	101.47 MB	310.85 MB	412.32 MB
9	Maschinenbau	887.32 KB	5.07 MB	5.93 MB
10	Multimedia	110.74 MB	582.51 MB	693.26 MB
11	PC-Pool Test	77.62 KB	3.88 MB	3.96 MB
12	Rechenzentrum	16.94 GB	8.52 GB	25.46 GB
13	Spider-Server	175.17 MB	7.64 MB	182.81 MB
14	VPN	871.02 MB	8.55 GB	9.40 GB
15	Verwaltung	76.20 MB	16.10 MB	92.30 MB
Tabellensumme		**44.95 GB**	**44.95 GB**	**89.89 GB**
CSV Export				

(from: isarflow.de)

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European Directive

Directive 2006/24/EC of the European Parliament and of the Council of 15 March 2006:

- *1. Member States shall ensure that the following categories of data are retained under this Directive:*
  - *(a) data necessary to trace and identify the source of a communication:*
    - *(1) concerning fixed network telephony and mobile telephony:*
      - *(i) the calling telephone number;*
      - *(ii) the name and address of the subscriber or registered user;*
    - *(2) concerning Internet access, Internet e-mail and Internet telephony:*
      - *(i) the user ID(s) allocated;*
      - *(ii) the user ID and telephone number allocated to any communication entering the public telephone network;*
      - *(iii) the name and address of the subscriber or registered user to whom an Internet Protocol (IP) address, user ID or telephone number was allocated at the time of the communication;*
  - *(b) data necessary to identify the destination of a communication:*
    - *…*

Measurements

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How to measure?

- Passive measurement:
  - Log files
  - Observe traffic
  - …
- Active measurement:
  - Send probing packets
  - Example: ping

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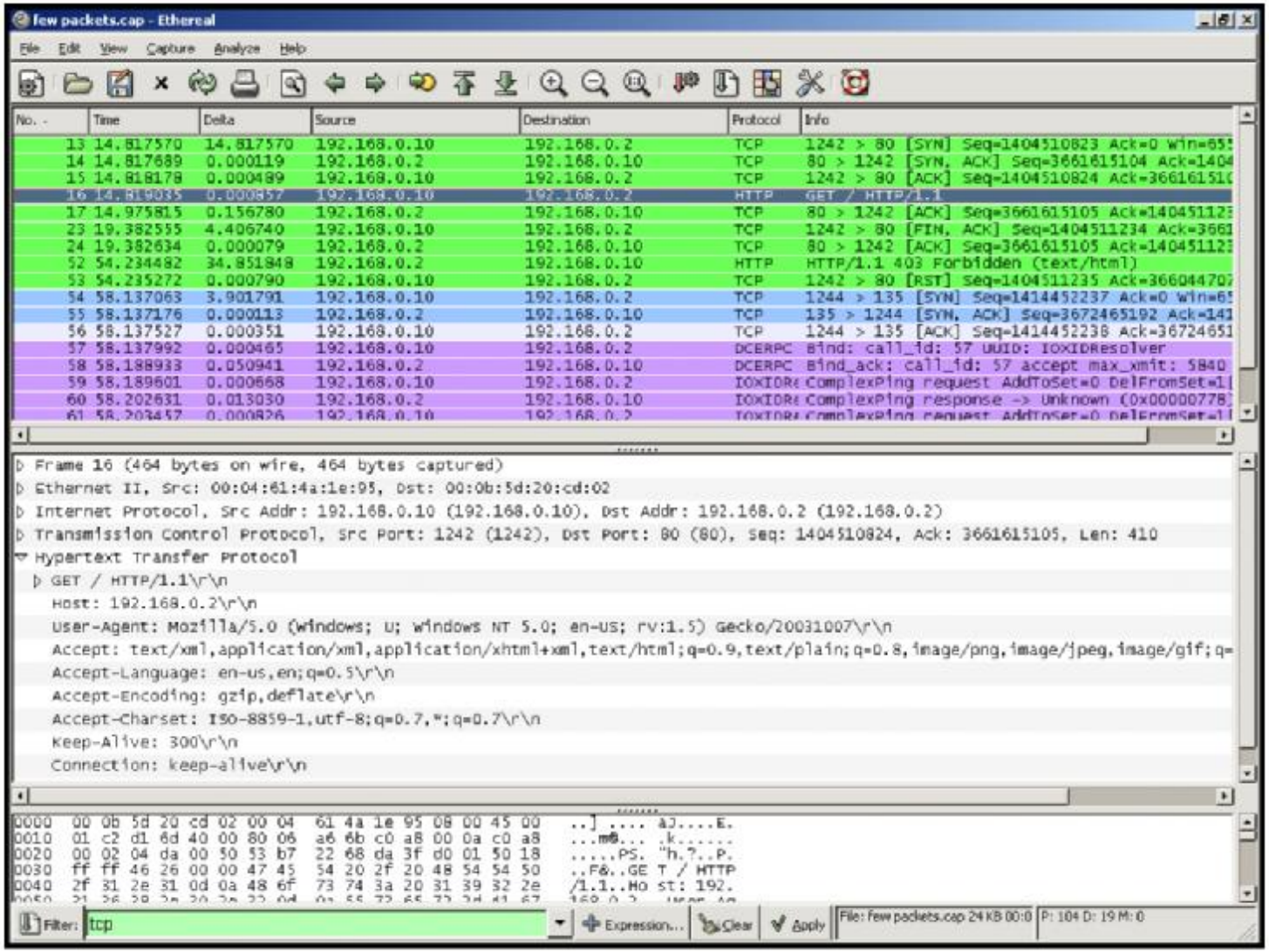
Record packets with tcpdump

- Capture network traffic (not only TCP) at specified interface
- Collected data stored as “pcap” files
- Can be used as library by other applications
- Many capturing options, filters,…
- Example:

```
tcpdump 'tcp[tcpflags] & (tcp-syn|tcp-fin)!=0'
```

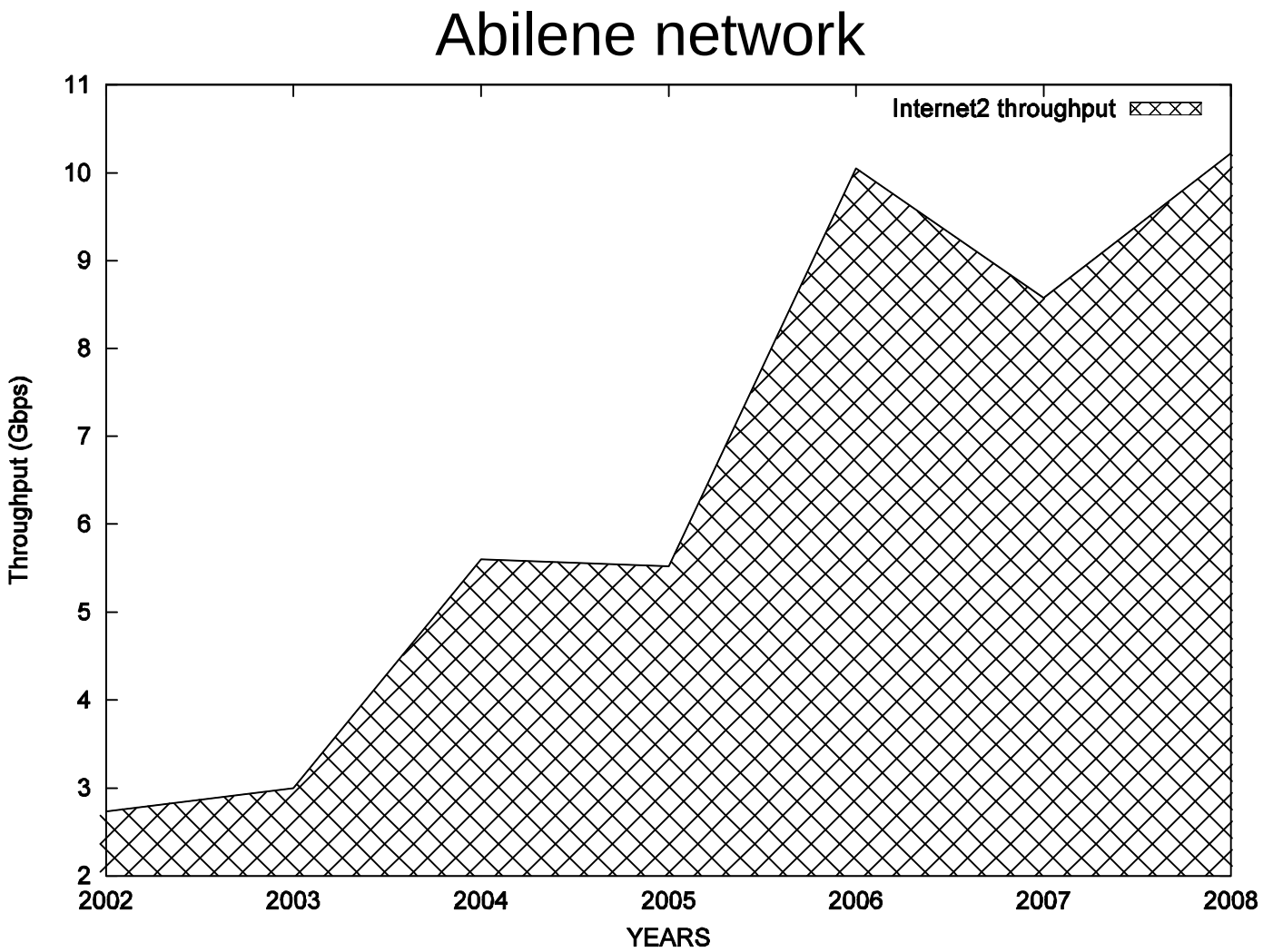
Wireshark


few packets.cap - Ethereal
File Edit View Capture Analyze Help
No. - Time Delta Source Destination Protocol Info
13 14.817570 14.817570 192.168.0.10 192.168.0.2 TCP 1242 > 80 [SYN] Seq=1404510823 Ack=0 Win=65
14 14.817689 0.000119 192.168.0.2 192.168.0.10 TCP 80 > 1242 [SYN, ACK] Seq=3661615104 Ack=1404
15 14.818178 0.000489 192.168.0.10 192.168.0.2 TCP 1242 > 80 [ACK] Seq=1404510824 Ack=366161510
16 14.819035 0.000857 192.168.0.10 192.168.0.2 HTTP GET / HTTP/1.1
17 14.975815 0.156780 192.168.0.2 192.168.0.10 TCP 80 > 1242 [ACK] Seq=3661615105 Ack=140451123
23 19.382555 4.406740 192.168.0.10 192.168.0.2 TCP 1242 > 80 [FIN, ACK] Seq=1404511234 Ack=3661
24 19.382634 0.000079 192.168.0.2 192.168.0.10 TCP 80 > 1242 [ACK] Seq=3661615105 Ack=140451123
52 54.234482 34.851848 192.168.0.2 192.168.0.10 HTTP HTTP/1.1 403 Forbidden (text/html)
53 54.235272 0.000790 192.168.0.10 192.168.0.2 TCP 1242 > 80 [RST] Seq=1404511235 Ack=366044707
54 58.137063 3.901791 192.168.0.10 192.168.0.2 TCP 1244 > 135 [SYN] Seq=1414452237 Ack=0 Win=65
55 58.137176 0.000113 192.168.0.2 192.168.0.10 TCP 135 > 1244 [SYN, ACK] Seq=3672465192 Ack=141
56 58.137527 0.000351 192.168.0.10 192.168.0.2 TCP 1244 > 135 [ACK] Seq=1414452238 Ack=367246515
57 58.137992 0.000465 192.168.0.10 192.168.0.2 DCERPC Bind: call_id: 57 UUID: IOXIDResolver
58 58.188933 0.050941 192.168.0.2 192.168.0.10 DCERPC Bind_ack: call_id: 57 accept max_xmit: 5840
59 58.189601 0.000668 192.168.0.10 192.168.0.2 IOXIDR ComplexPing request AddToSet=0 DelFromSet=1
60 58.202631 0.013030 192.168.0.2 192.168.0.10 IOXIDR ComplexPing response -> Unknown (0x00000778)
Frame 16 (464 bytes on wire, 464 bytes captured)
Ethernet II, Src: 00:04:61:4a:1e:95, Dst: 00:0b:5d:20:cd:02
Internet Protocol, Src Addr: 192.168.0.10 (192.168.0.10), Dst Addr: 192.168.0.2 (192.168.0.2)
Transmission Control Protocol, Src Port: 1242 (1242), Dst Port: 80 (80), Seq: 1404510824, Ack: 3661615105, Len: 410
Hypertext Transfer Protocol
GET / HTTP/1.1\r\n
Host: 192.168.0.2\r\n
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.0; en-US; rv:1.5) Gecko/20031007\r\n
Accept: text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.8,image/png,image/jpeg,image/gif;q=
Accept-Language: en-us,en;q=0.5\r\n
Accept-Encoding: gzip,deflate\r\n
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\n
Keep-Alive: 300\r\n
Connection: keep-alive\r\n
0000 00 0b 5d 20 cd 02 00 04 61 4a 1e 95 08 00 45 00 ..] .... aJ....E.
0010 01 c2 d1 6d 40 00 80 06 a6 6b c0 a8 00 0a c0 a8 ...m@... .k......
0020 00 02 04 da 00 50 53 b7 22 68 da 3f d0 01 50 18 .....PS. "h.?..P.
0030 ff ff 46 26 00 00 47 45 54 20 2f 20 48 54 54 50 ..F&..GE T / HTTP
0040 2f 31 2e 31 0d 0a 48 6f 73 74 3a 20 31 39 32 2e /1.1..Ho st: 192.
Filter: tcp
Expression... Clear Apply
File: few packets.cap 24 KB 00:0
P: 104 D: 19 M: 0

Location of Measurement

- Single hosts:
  - Only traffic directed to/generated by the host
  - All traffic seen on the network segment
- Switches, routers:
  1. Create mirror port (Cisco: SPAN-Port) for one or more source ports
  2. Send traffic from mirror port to a measurement host
- Packet loss if traffic throughput is…
  - > mirror port bandwidth
  - > storage/processing rate at measurement host

Limitations of Packet Measurement



Limitations of Packet Measurement

Collect and process less information:

- Only collect packet headers, not payload
- Ignore single packets (aggregate)
- Ignore some packets (sampling)

Make collection and processing faster:

- Move to kernel space
- Distributed collection & processing
- Dedicated hardware

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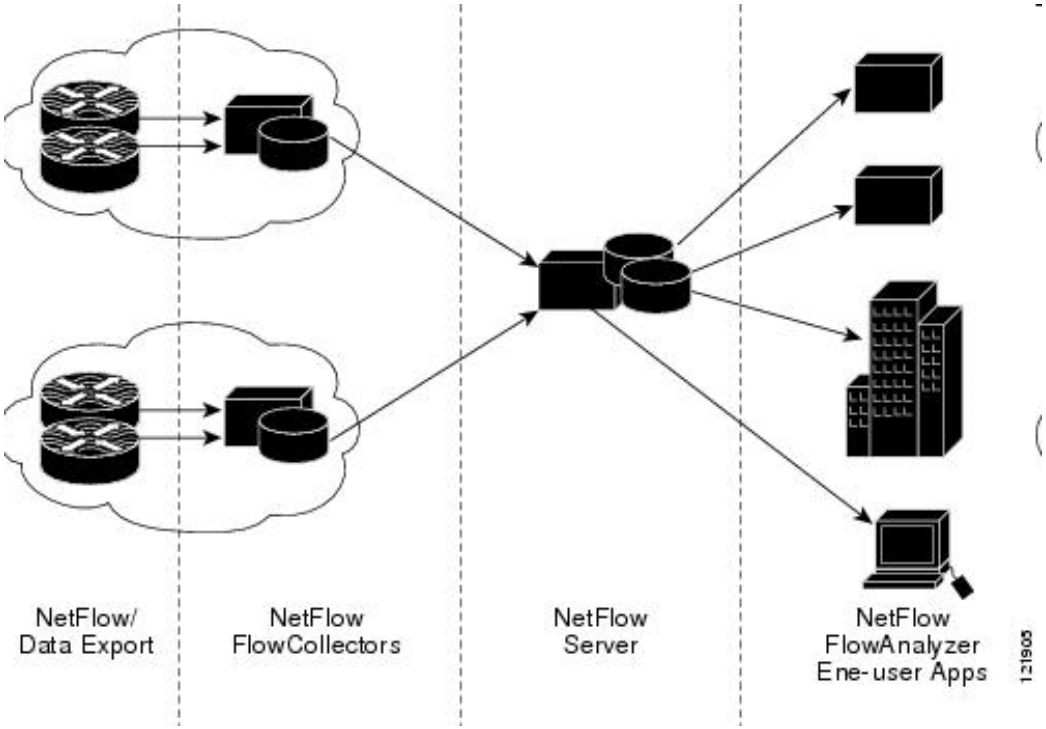
Sflow, Netflow, IPFIX

A flow “summarizes” a sequence of packets:

- Source & destination IP address
- Source & destination port number
- Source & destination AS
- Layer 3 protocol type
- Size (aggregated number of bytes)
- Timestamps of first and last packet
- …

NetFlow infrastructure



Protocols:

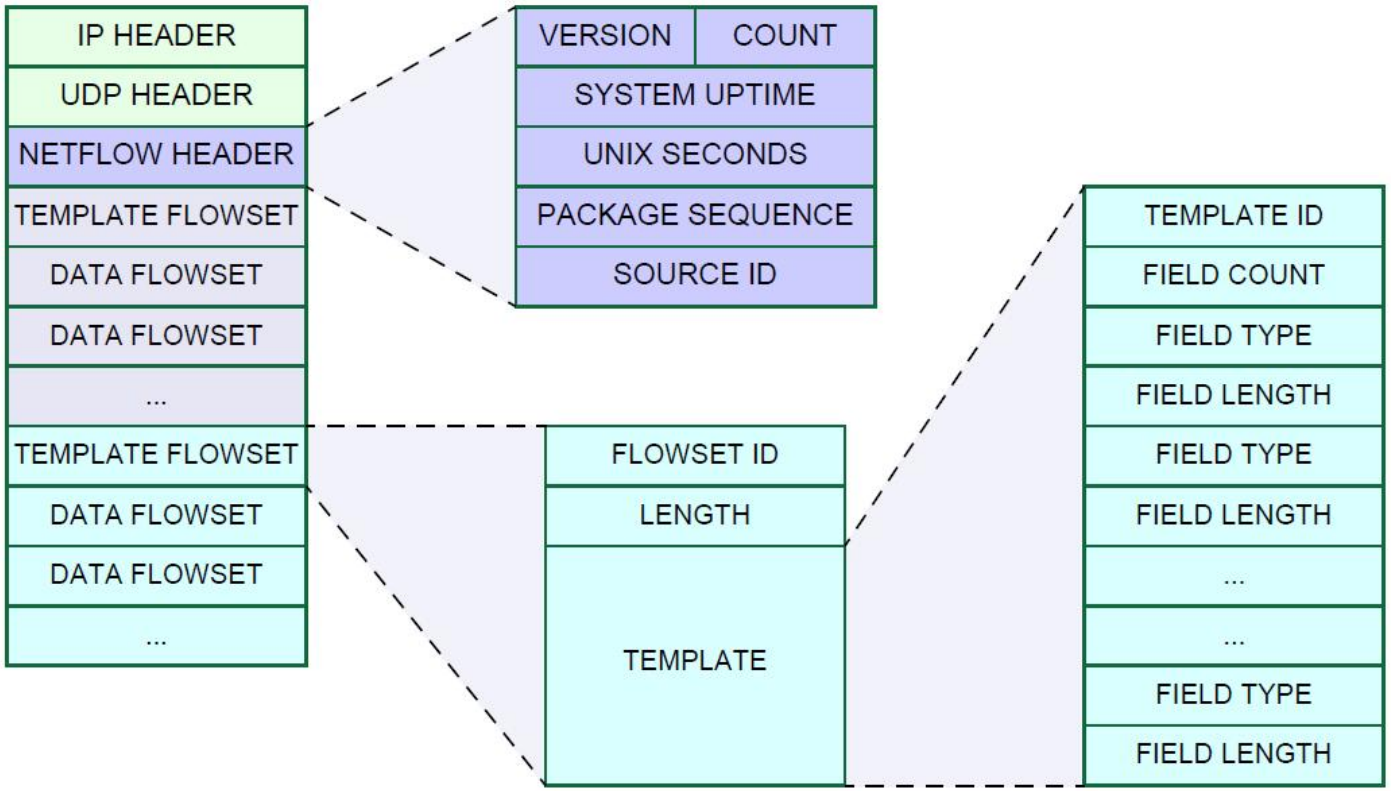
- Netflow v5, 9: quasi-standard. by Cisco
- IPFIX: from Netflow v9, by IETF

(from: Cisco)

Flexible Netflow: flexible monitoring, by Cisco

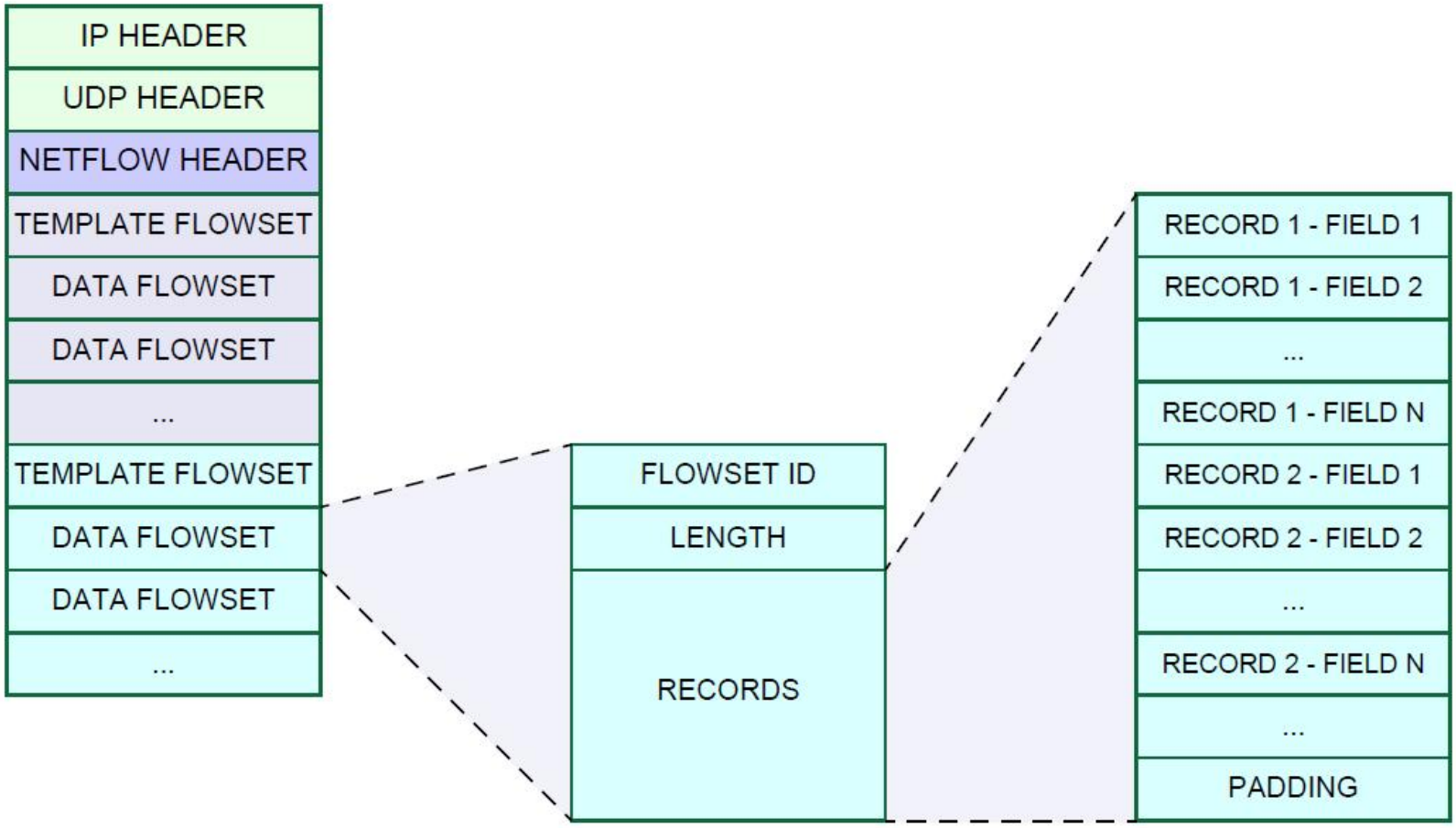
Netflow v9

Exported data specified by templates (≠ v5)



from: Cisco

Netflow v9



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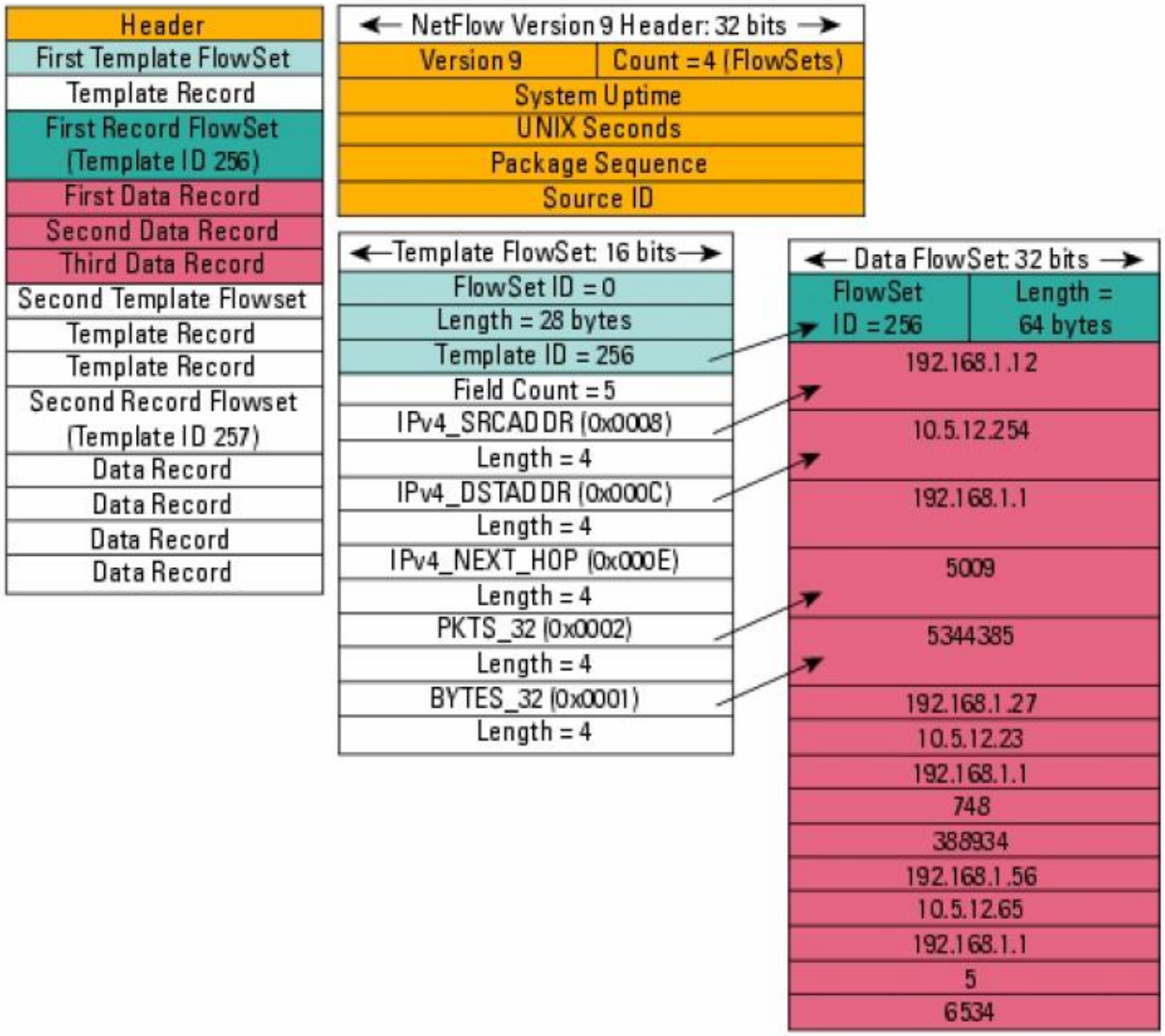
Netflow v9



(from: Cisco)

Flows vs. Packets

- Of course, loss of information (no payload, no details of packet headers)
- But sometimes the only option
- Still useful for:
  - Accounting
  - Interception
  - Even intrusion detection:
    - Scans
    - Some kinds of DoS
    - …