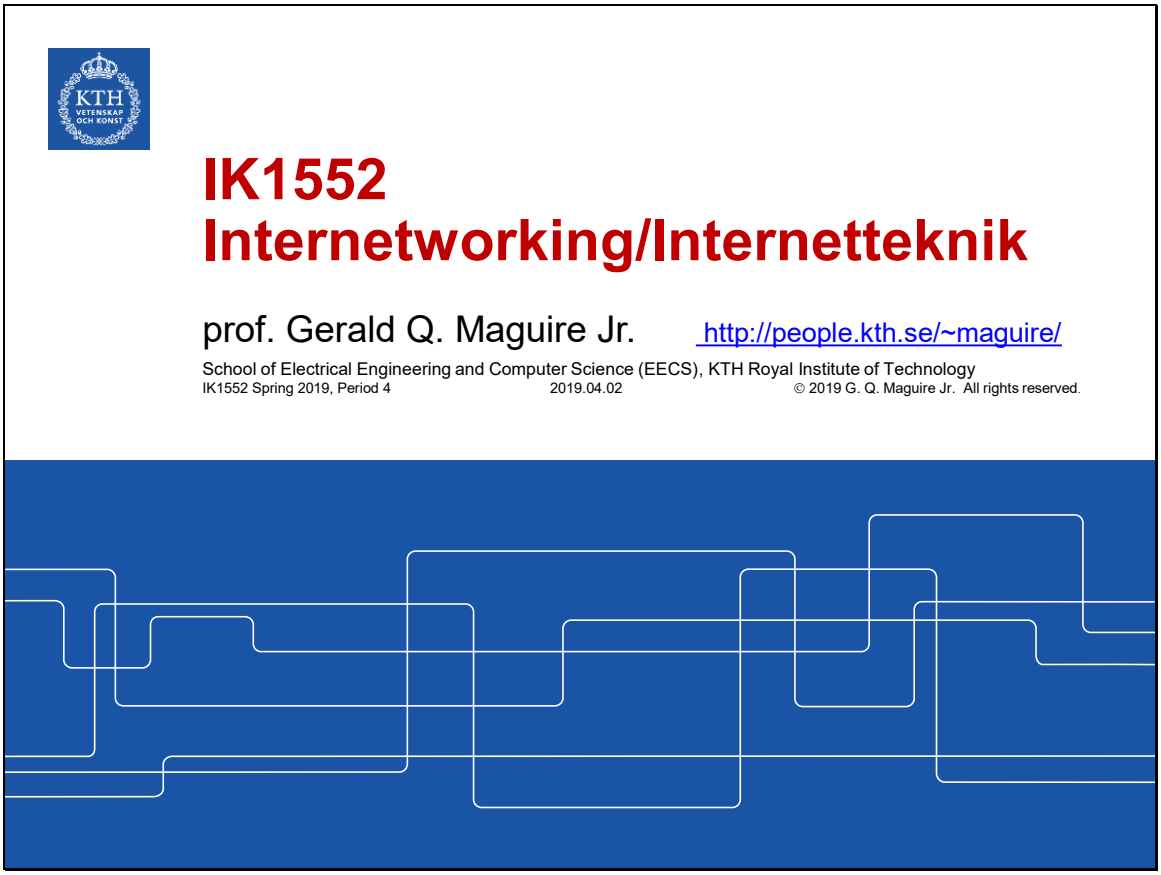
Slide 1


IK1552
Internetworking/Internetteknik
prof. Gerald Q. Maguire Jr.
http://people.kth.se/~maguire/
School of Electrical Engineering and Computer Science (EECS), KTH Royal Institute of Technology
IK1552 Spring 2019, Period 4
2019.04.02
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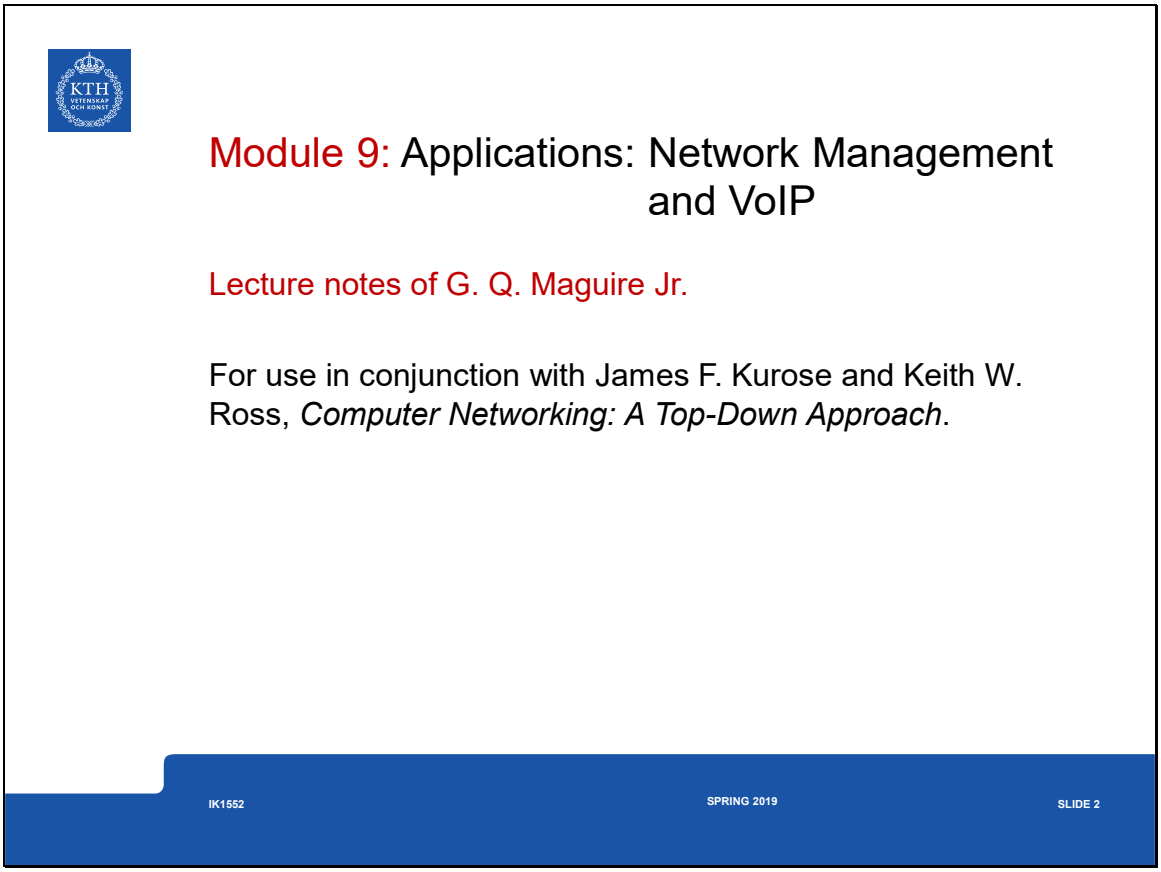
Slide 2


Module 9: Applications: Network Management and VoIP
Lecture notes of G. Q. Maguire Jr.
For use in conjunction with James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach.
IK1552
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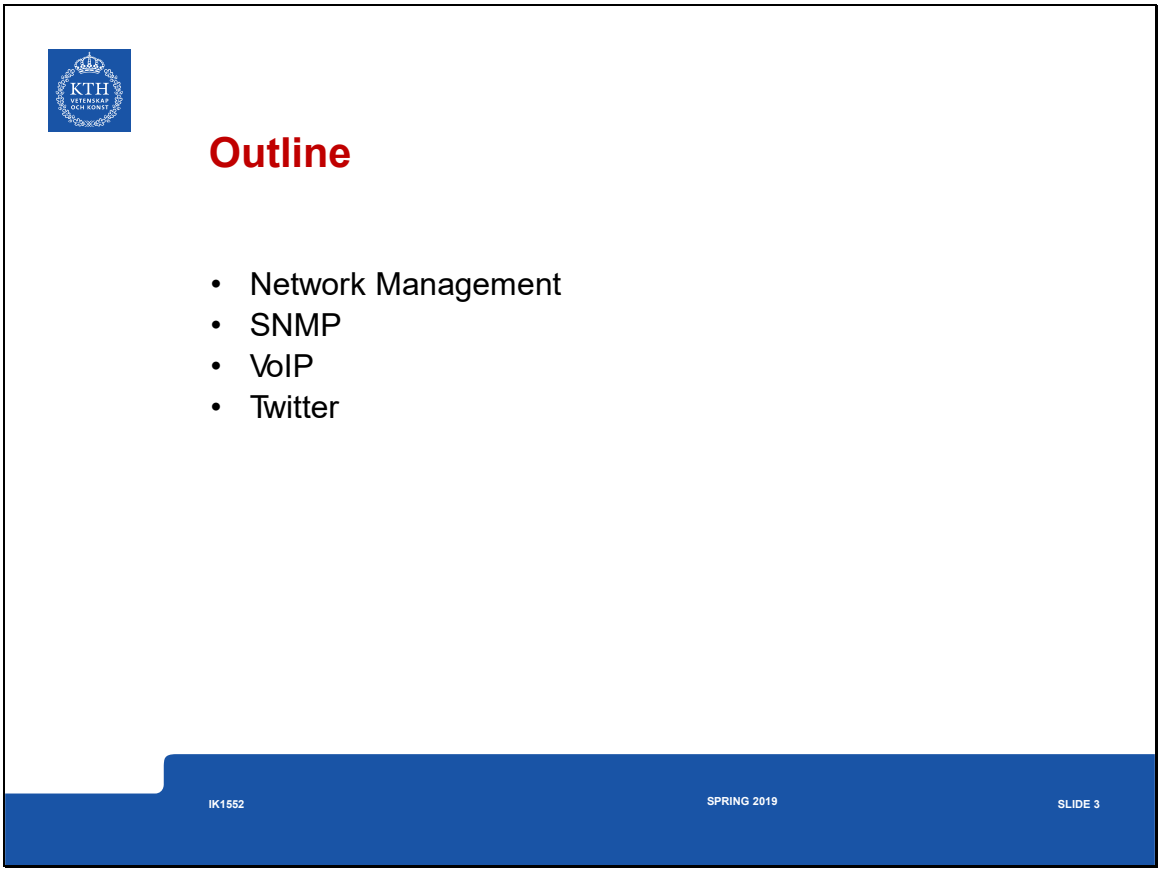
SLIDE 2

Slide 3


Outline
• Network Management
• SNMP
• VoIP
• Twitter
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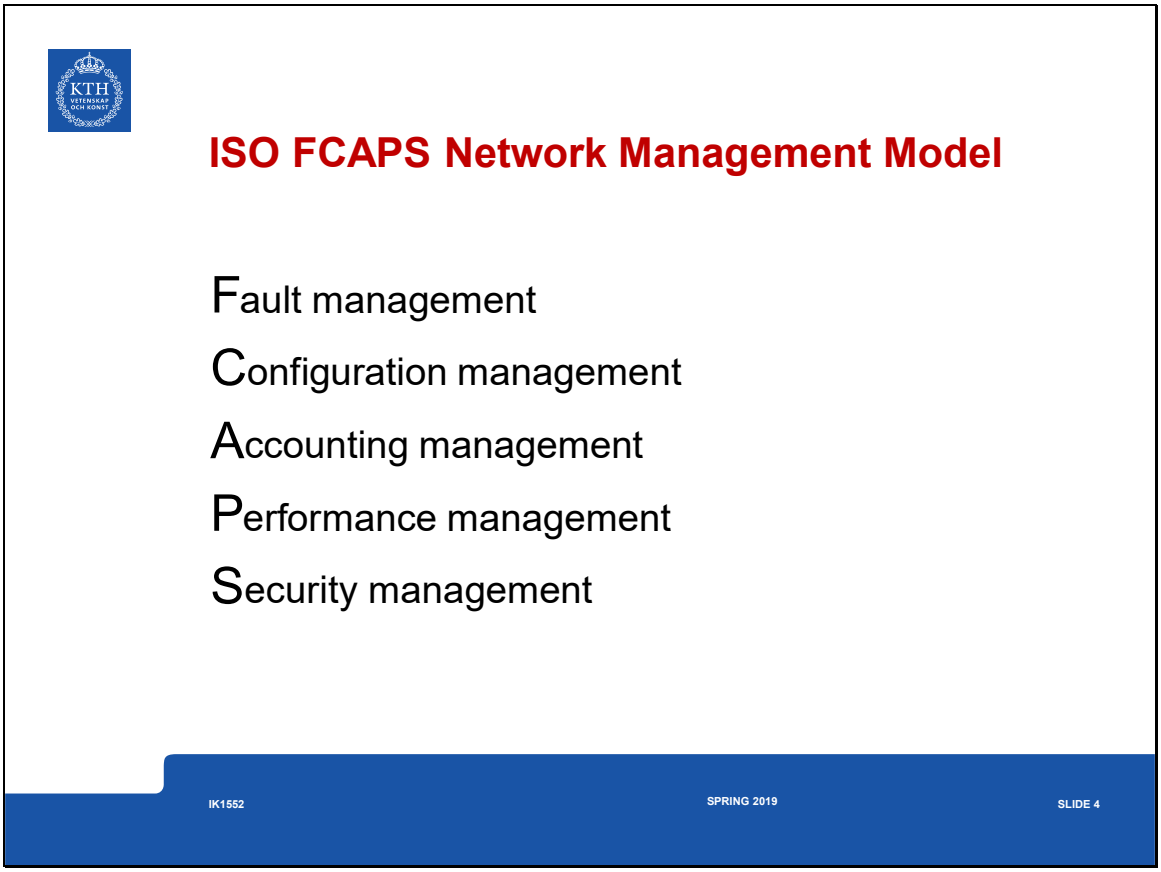
SLIDE 3

Slide 4


ISO FCAPS Network Management Model
Fault management
Configuration management
Accounting management
Performance management
Security management
IK1552
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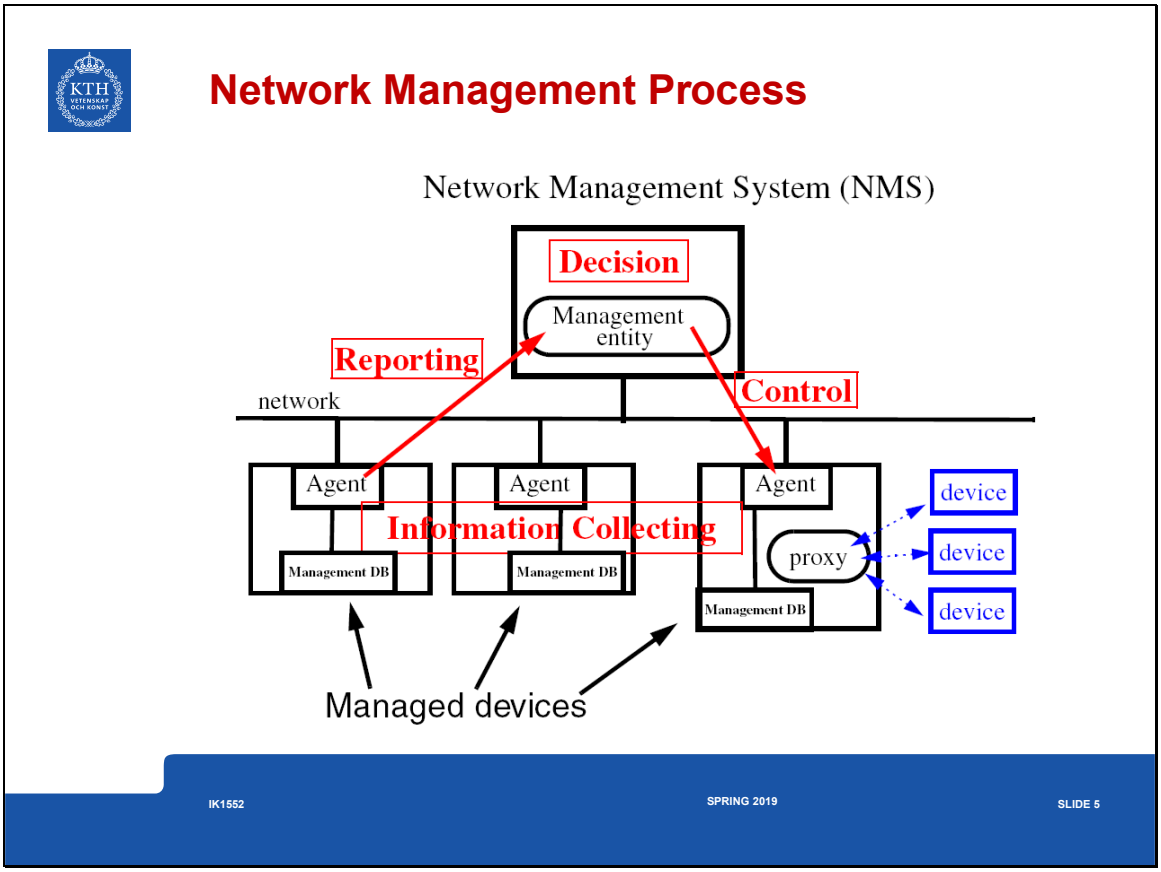
SLIDE 4

Slide 5


Network Management Process
Network Management System (NMS)
Decision
Management entity
Reporting
Control
network
Agent
Agent
Agent
Information Collecting
Management DB
Management DB
Management DB
proxy
device
device
device
Managed devices
IK1552
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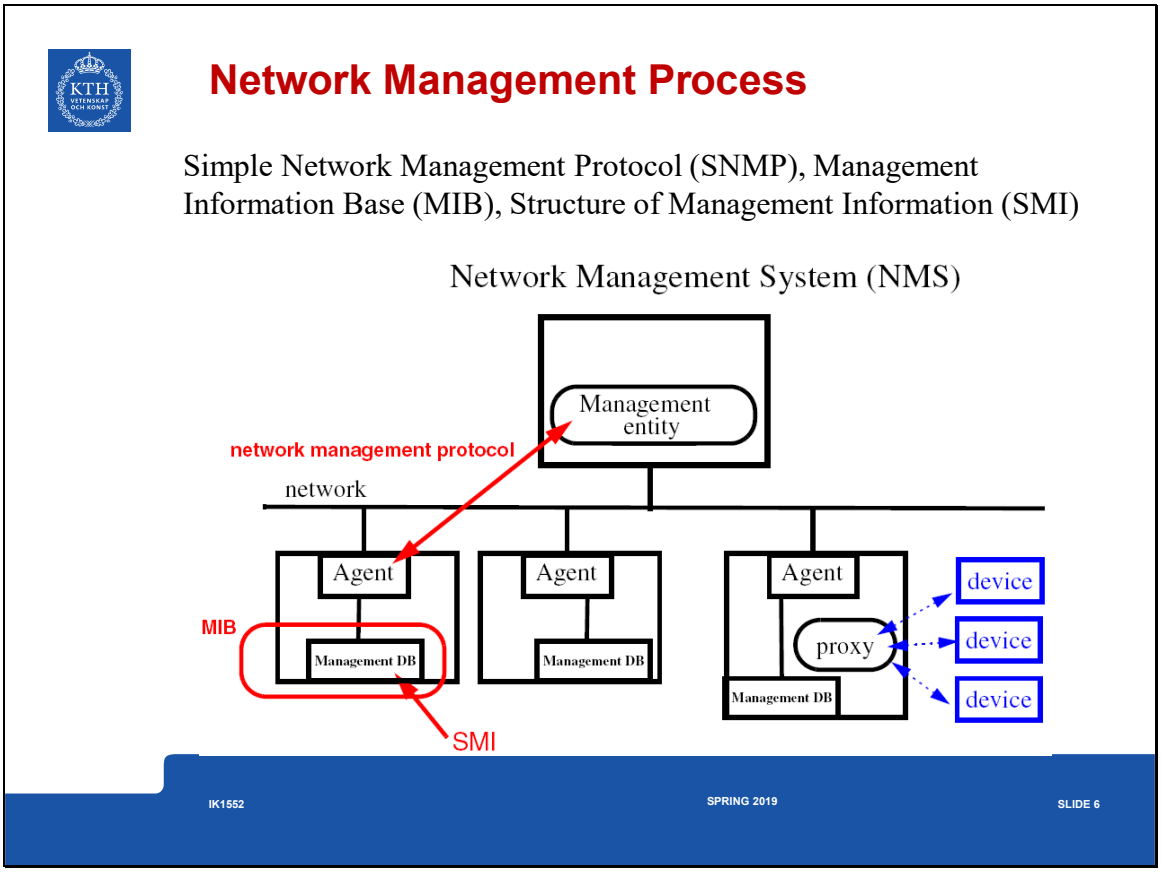
SLIDE 5

Slide 6


Network Management Process
Simple Network Management Protocol (SNMP), Management Information Base (MIB), Structure of Management Information (SMI)
Network Management System (NMS)
Management entity
network management protocol
network
Agent
Agent
Agent
MIB
Management DB
Management DB
Management DB
proxy
device
device
device
SMI
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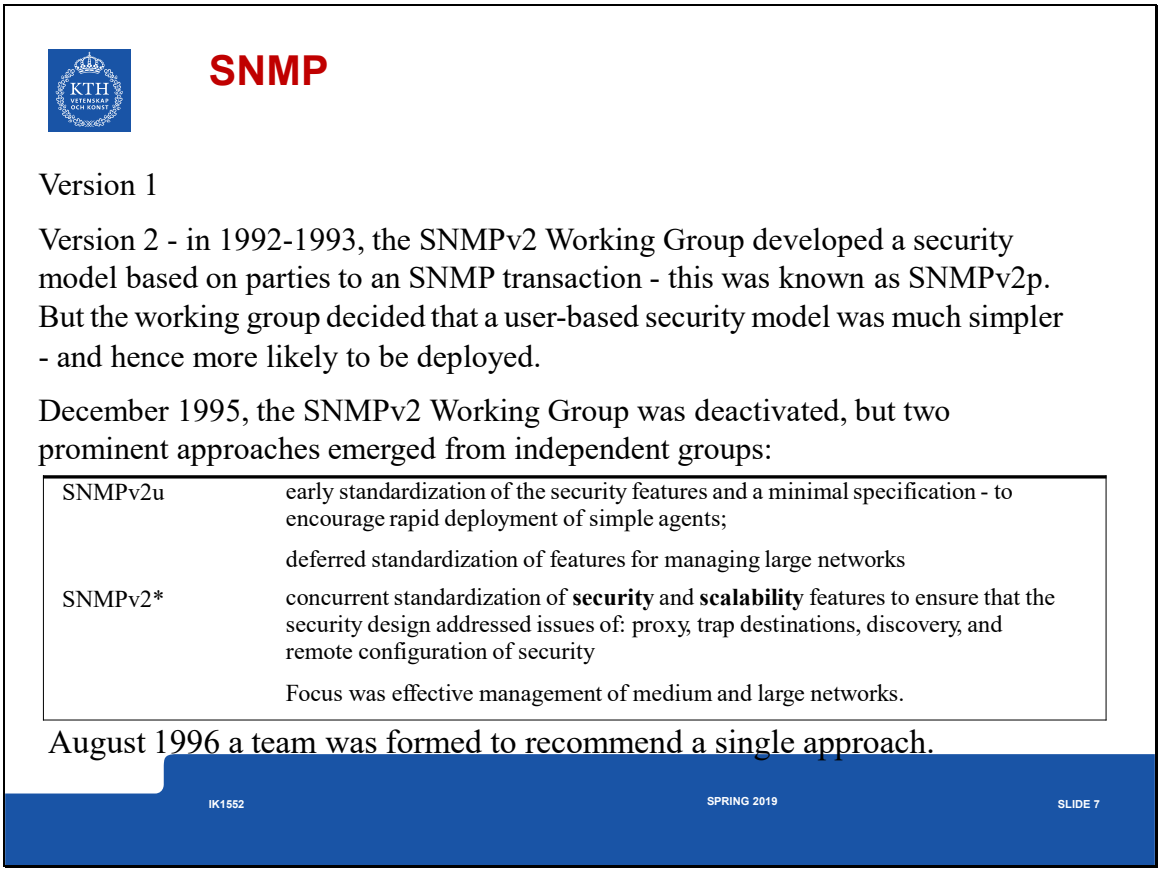
SLIDE 6

Slide 7



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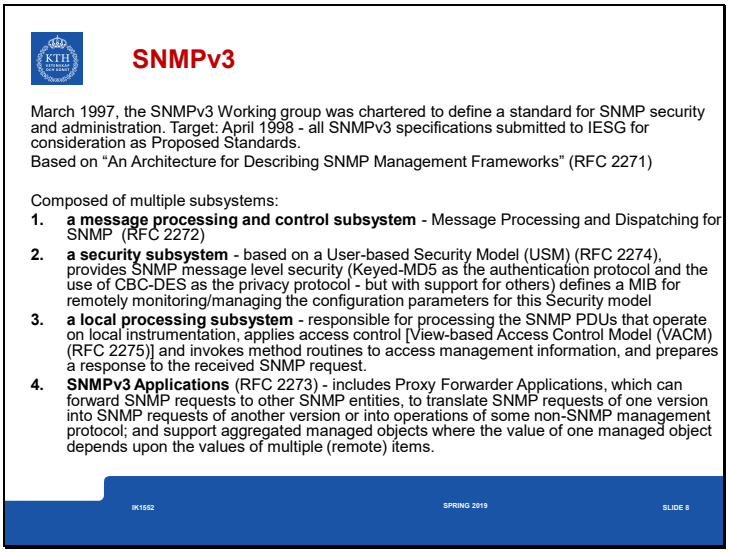
http://www.simple-times.org/pub/simple-times/usec/v2compare.html

Slide 8



J. Case, D. Harrington, R. Presuhn, and B. Wijnen, 'Message Processing and Dispatching for the Simple Network Management Protocol (SNMP)', *Internet Request for Comments*, vol. RFC 2272 (Proposed Standard), January 1998, Available at http://www.rfc-editor.org/rfc/rfc2272.txt

D. Harrington, R. Presuhn, and B. Wijnen, 'An Architecture for Describing SNMP Management Frameworks', *Internet Request for Comments*, vol. RFC 2261 (Proposed Standard), January 1998, Available at http://www.rfc-editor.org/rfc/rfc2261.txt

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D. Levi, P. Meyer, and B. Stewart, 'SNMPv3 Applications', *Internet Request for Comments*, vol. RFC 2273 (Proposed Standard), January 1998, Available at http://www.rfc-editor.org/rfc/rfc2273.txt

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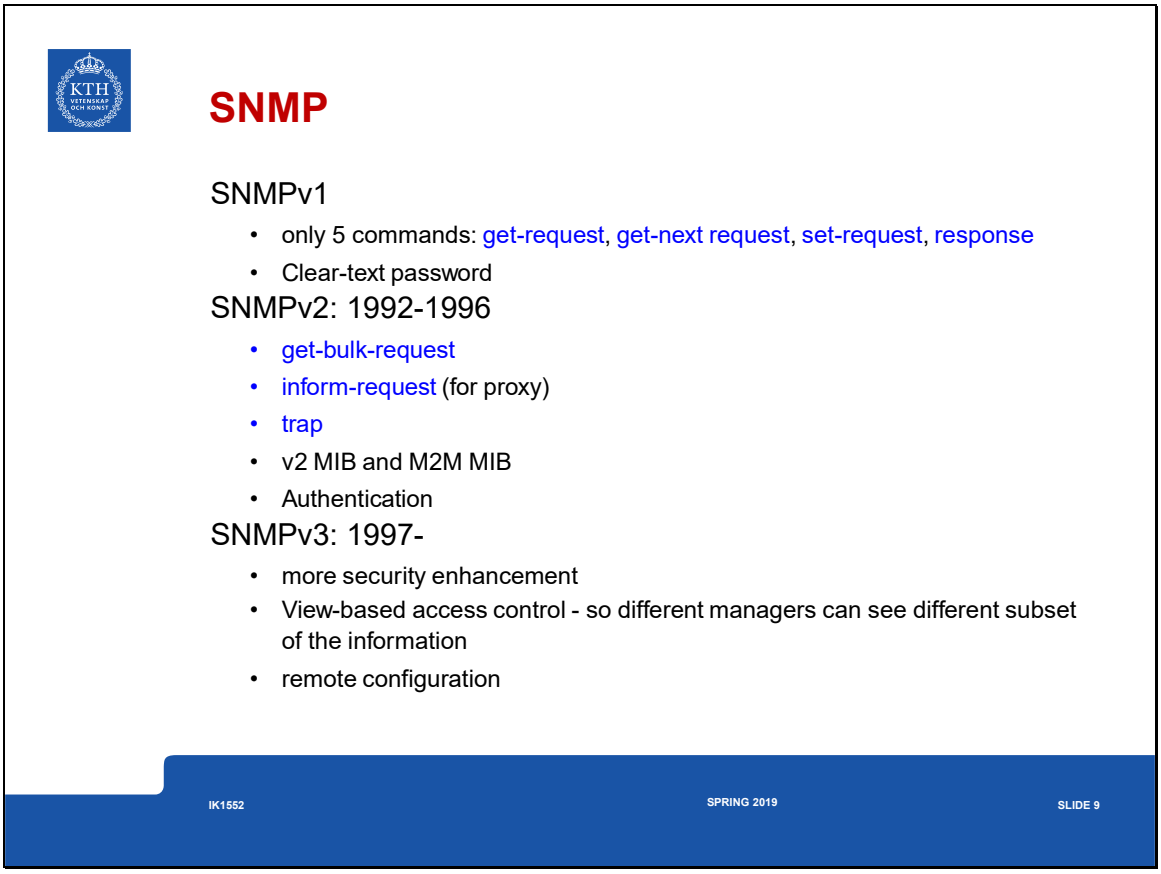
SNMP
SNMPv1
only 5 commands: get-request, get-next request, set-request, response
Clear-text password
SNMPv2: 1992-1996
get-bulk-request
inform-request (for proxy)
trap
v2 MIB and M2M MIB
Authentication
SNMPv3: 1997-
more security enhancement
View-based access control - so different managers can see different subset of the information
remote configuration
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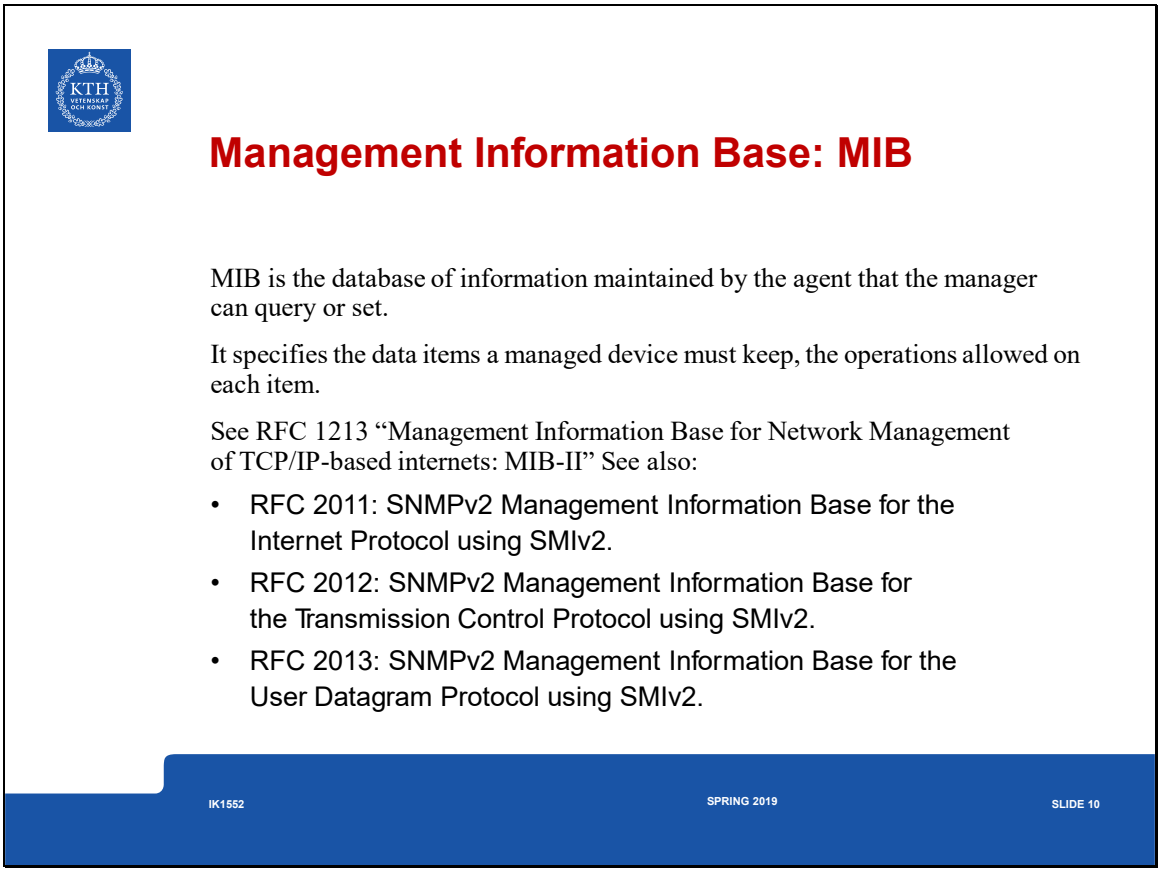

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K. McCloghrie, 'SNMPv2 Management Information Base for the Internet Protocol using SMIv2', *Internet Request for Comments*, vol. RFC 2011 (Proposed Standard), November 1996, Available at http://www.rfc-editor.org/rfc/rfc2011.txt

K. McCloghrie, 'SNMPv2 Management Information Base for the Transmission Control Protocol using SMIv2', *Internet Request for Comments*, vol. RFC 2012 (Proposed Standard), November 1996, Available at http://www.rfc-editor.org/rfc/rfc2012.txt

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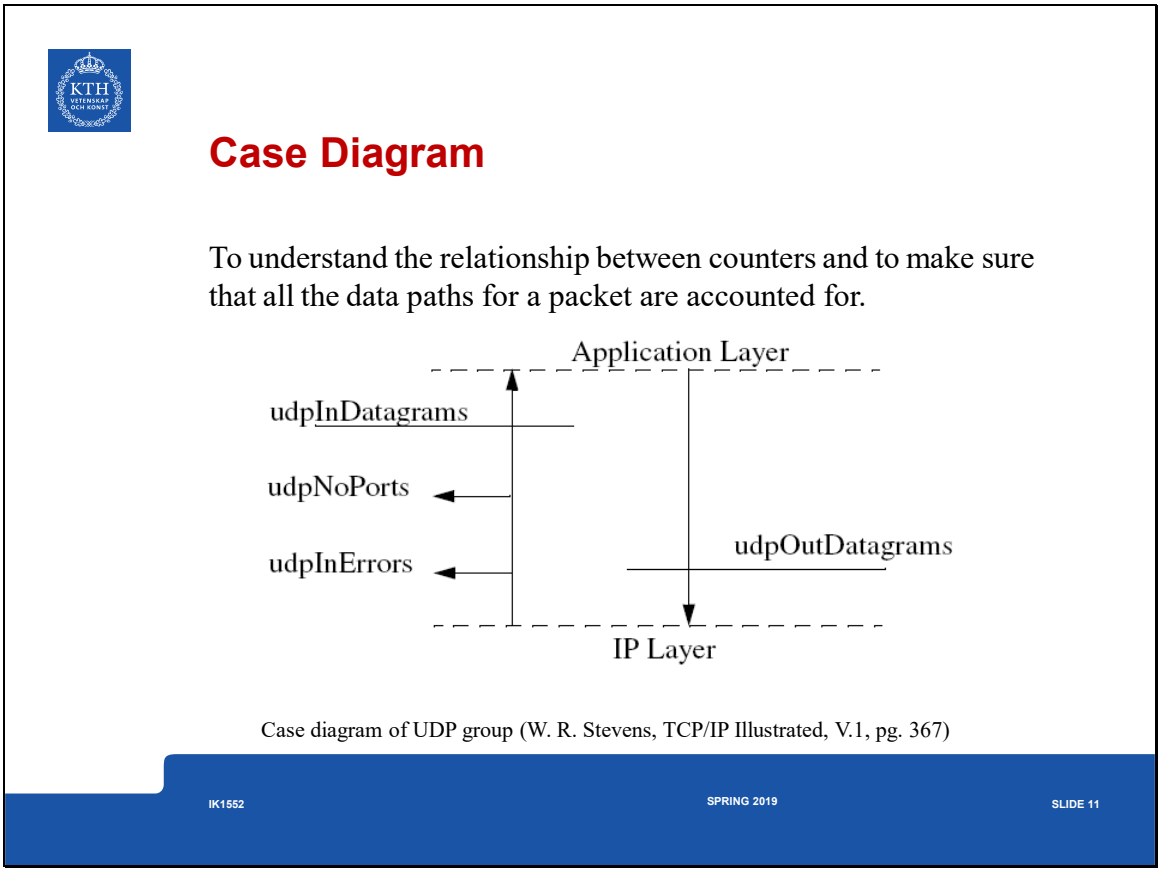
B. Fenner and J. Flick, 'Management Information Base for the User Datagram Protocol (UDP)', *Internet Request for Comments*, vol. RFC 4113 (Proposed Standard), June 2005, Available at http://www.rfc-editor.org/rfc/rfc4113.txt

Slide 11


Case Diagram
To understand the relationship between counters and to make sure that all the data paths for a packet are accounted for.
Application Layer
udpInDatagrams
udpNoPorts
udpInErrors
udpOutDatagrams
IP Layer
Case diagram of UDP group (W. R. Stevens, TCP/IP Illustrated, V.1, pg. 367)
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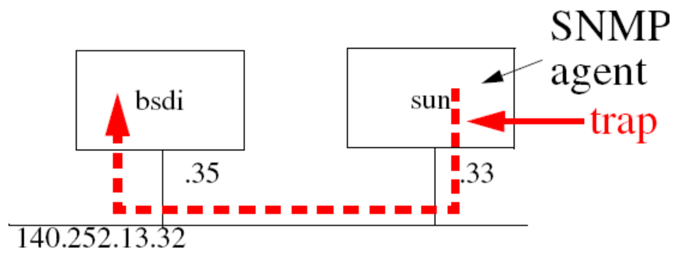
SNMP Traps

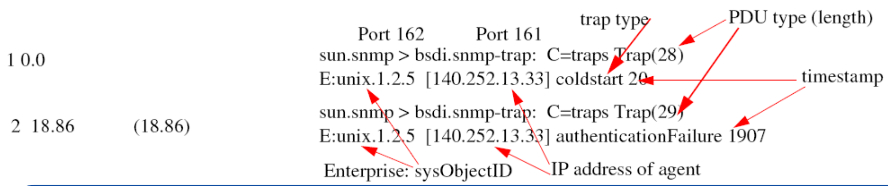
Agent sends a trap to manager to indicate that something has happened.

Following trap types are defined:

0: coldStart
1: warmStart
2: linkDown
3: linkUP
4: authenticationFailure
5: egpNeighborLoss
6: enterpriseSpecific



Example: start the SNMP agent on sun and send traps to bsdi; tcpdump output:



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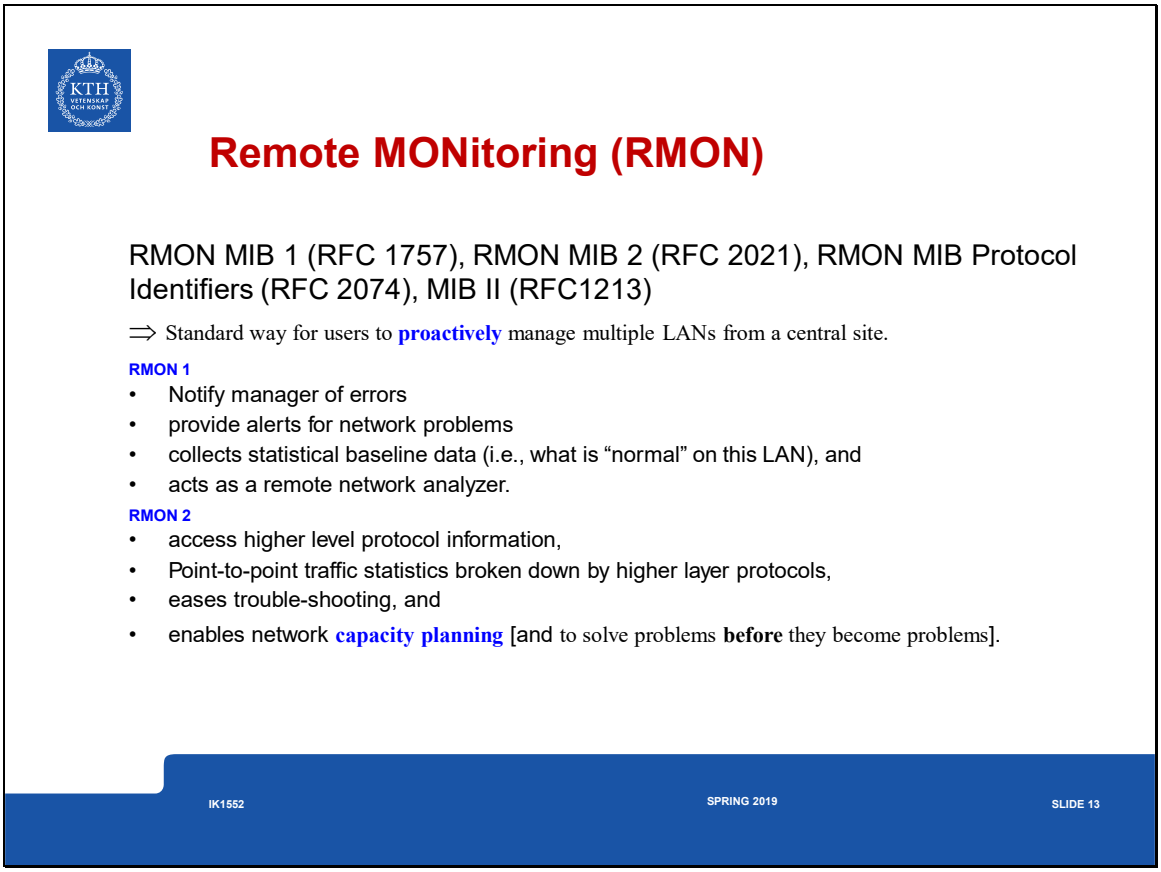

S. Waldbusser, 'Remote Network Monitoring Management Information Base', *Internet Request for Comments*, vol. RFC 1757 (Draft Standard), February 1995, Available at http://www.rfc-editor.org/rfc/rfc1757.txt

S. Waldbusser, 'Remote Network Monitoring Management Information Base Version 2 using SMIv2', *Internet Request for Comments*, vol. RFC 2021 (Proposed Standard), January 1997, Available at http://www.rfc-editor.org/rfc/rfc2021.txt

A. Bierman and R. Iddon, 'Remote Network Monitoring MIB Protocol Identifiers', *Internet Request for Comments*, vol. RFC 2074 (Proposed Standard), January 1997, Available at http://www.rfc-editor.org/rfc/rfc2074.txt

K. McCloghrie and M. Rose, 'Management Information Base for Network Management of TCP/IP-based internets:MIB-II', *Internet Request for Comments*, vol. RFC 1213 (Standard), March 1991, Available at http://www.rfc-editor.org/rfc/rfc1213.txt

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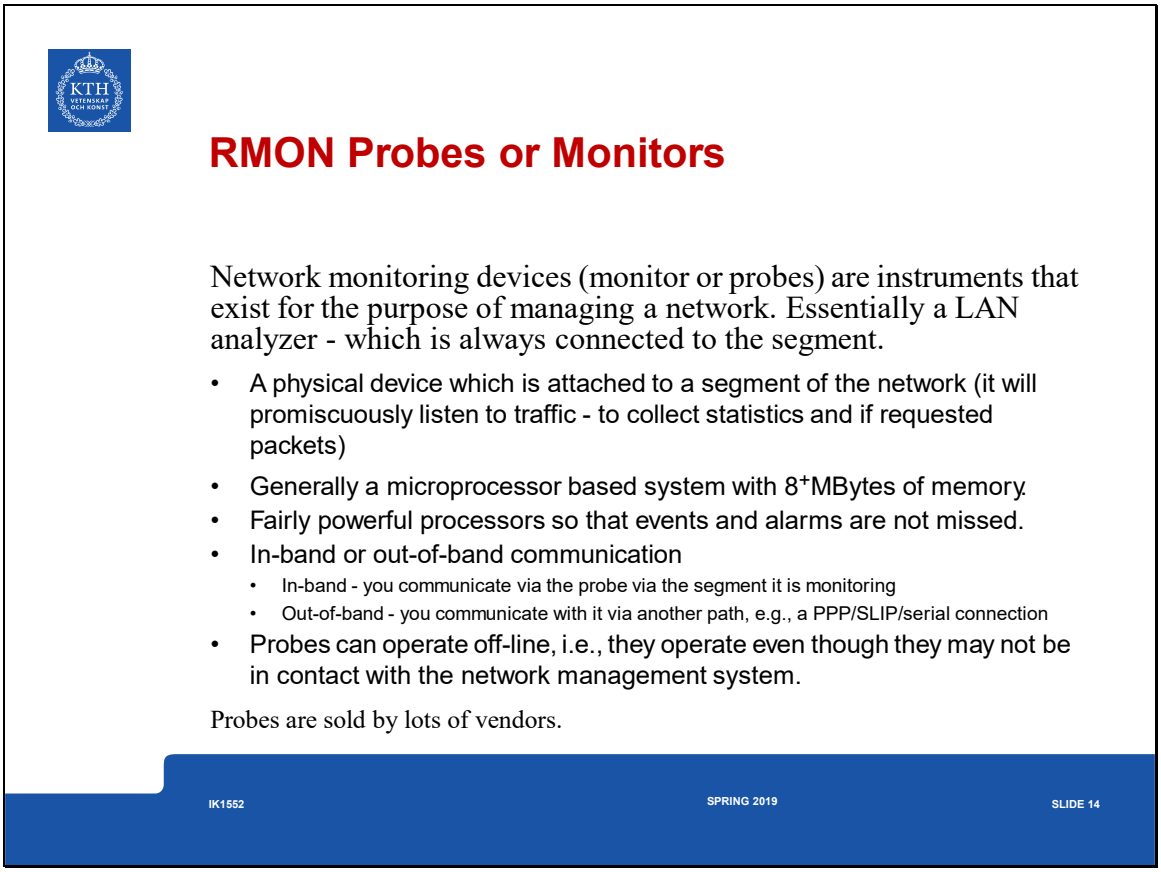
RMON Probes or Monitors
Network monitoring devices (monitor or probes) are instruments that exist for the purpose of managing a network. Essentially a LAN analyzer - which is always connected to the segment.
• A physical device which is attached to a segment of the network (it will promiscuously listen to traffic - to collect statistics and if requested packets)
• Generally a microprocessor based system with 8+MBytes of memory.
• Fairly powerful processors so that events and alarms are not missed.
• In-band or out-of-band communication
• In-band - you communicate via the probe via the segment it is monitoring
• Out-of-band - you communicate with it via another path, e.g., a PPP/SLIP/serial connection
• Probes can operate off-line, i.e., they operate even though they may not be in contact with the network management system.
Probes are sold by lots of vendors.
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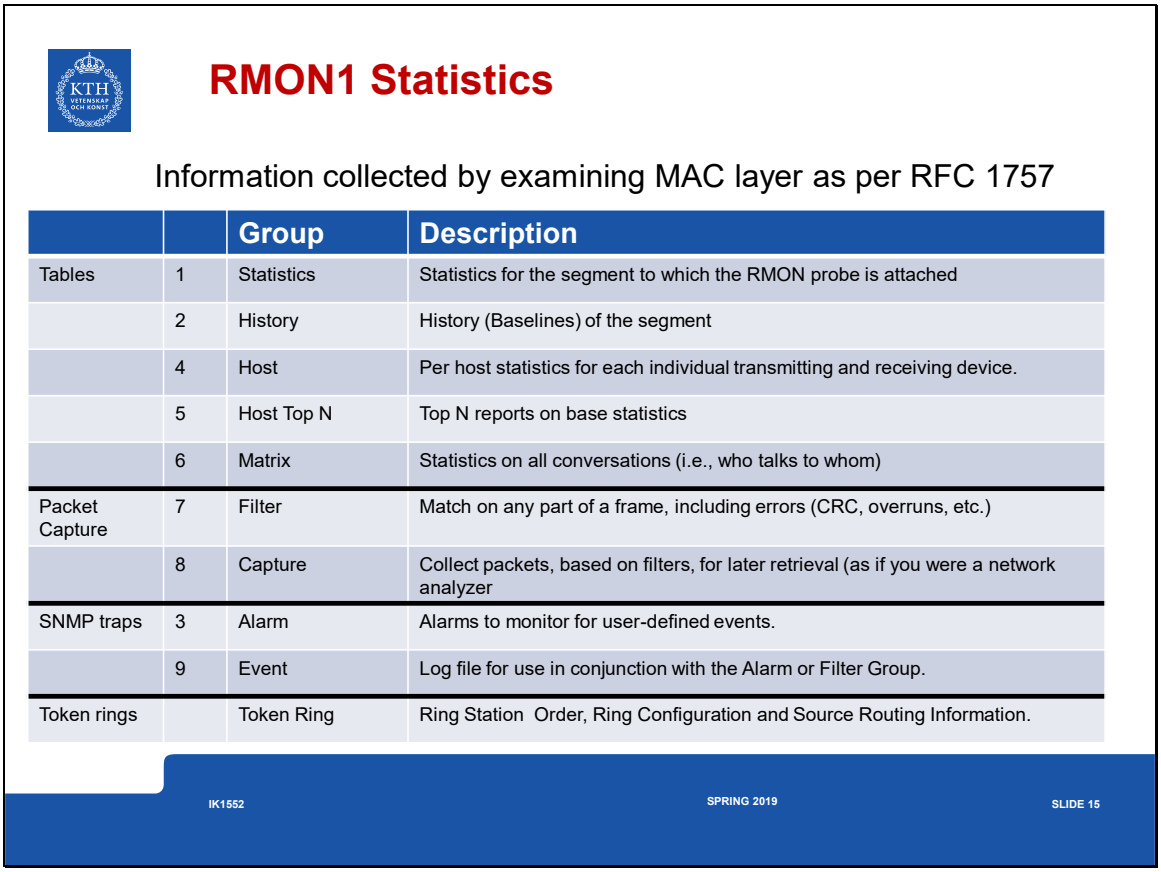

RMON1 Statistics

Information collected by examining MAC layer as per RFC 1757

		Group	Description
Tables	1	Statistics	Statistics for the segment to which the RMON probe is attached
	2	History	History (Baselines) of the segment
	4	Host	Per host statistics for each individual transmitting and receiving device.
	5	Host Top N	Top N reports on base statistics
	6	Matrix	Statistics on all conversations (i.e., who talks to whom)
Packet Capture	7	Filter	Match on any part of a frame, including errors (CRC, overruns, etc.)
	8	Capture	Collect packets, based on filters, for later retrieval (as if you were a network analyzer
SNMP traps	3	Alarm	Alarms to monitor for user-defined events.
	9	Event	Log file for use in conjunction with the Alarm or Filter Group.
Token rings		Token Ring	Ring Station Order, Ring Configuration and Source Routing Information.

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S. Waldbusser, 'Remote Network Monitoring Management Information Base', *Internet Request for Comments*, vol. RFC 1757 (Draft Standard), February 1995, Available at http://www.rfc-editor.org/rfc/rfc1757.txt

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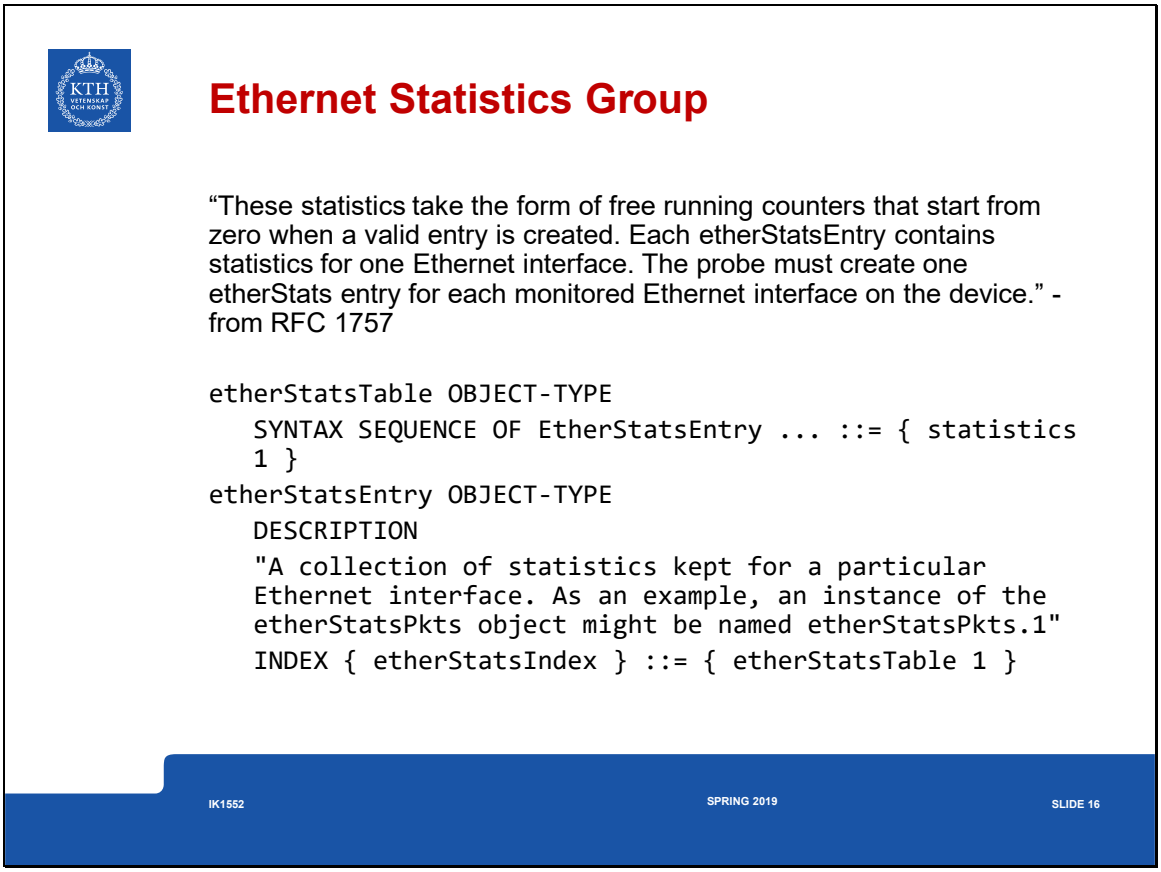
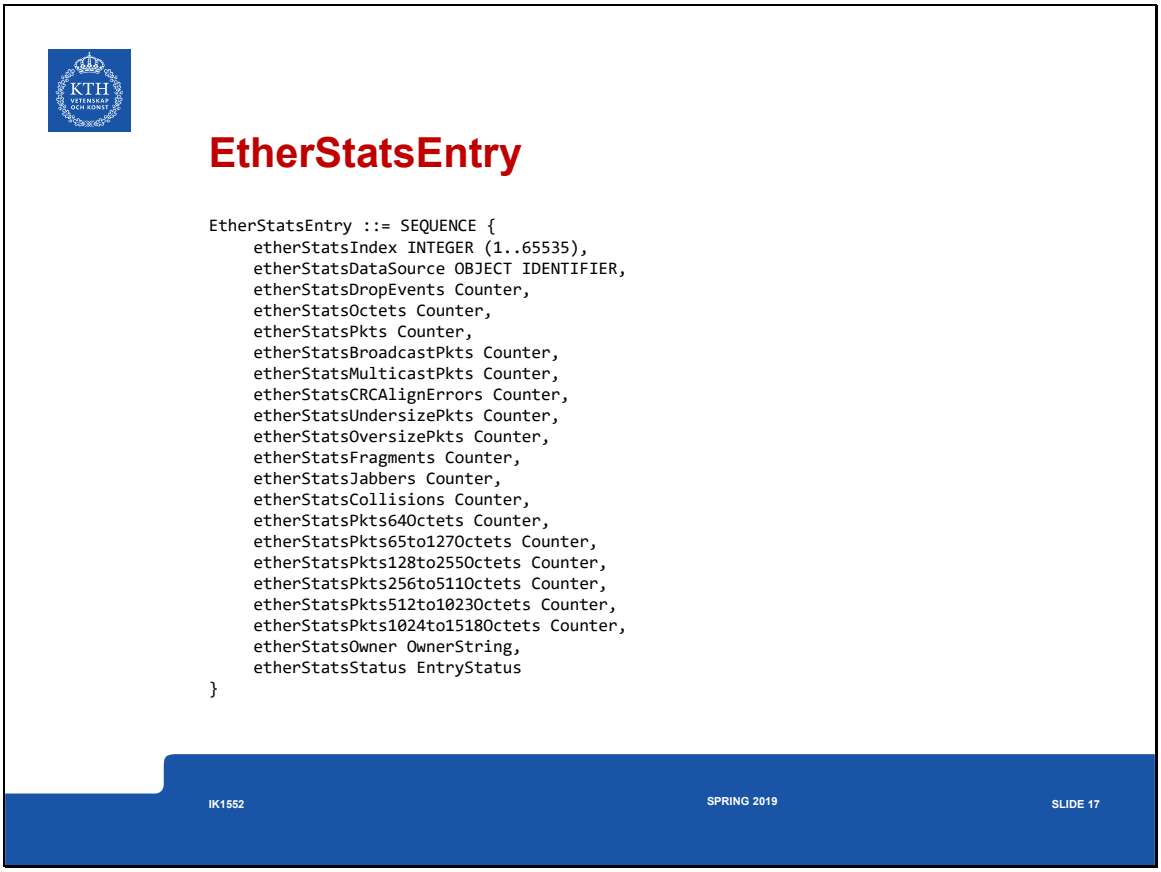


S. Waldbusser, 'Remote Network Monitoring Management Information Base', *Internet Request for Comments*, vol. RFC 1271 (Proposed Standard), November 1991, Available at http://www.rfc-editor.org/rfc/rfc1271.txt

S. Waldbusser, 'Remote Network Monitoring Management Information Base', *Internet Request for Comments*, vol. RFC 1757 (Draft Standard), February 1995, Available at http://www.rfc-editor.org/rfc/rfc1757.txt

Slide 17


EtherStatsEntry
EtherStatsEntry ::= SEQUENCE {
etherStatsIndex INTEGER (1..65535),
etherStatsDataSource OBJECT IDENTIFIER,
etherStatsDropEvents Counter,
etherStatsOctets Counter,
etherStatsPkts Counter,
etherStatsBroadcastPkts Counter,
etherStatsMulticastPkts Counter,
etherStatsCRCAlignErrors Counter,
etherStatsUndersizePkts Counter,
etherStatsOversizePkts Counter,
etherStatsFragments Counter,
etherStatsJabbers Counter,
etherStatsCollisions Counter,
etherStatsPkts64Octets Counter,
etherStatsPkts65to127Octets Counter,
etherStatsPkts128to255Octets Counter,
etherStatsPkts256to511Octets Counter,
etherStatsPkts512to1023Octets Counter,
etherStatsPkts1024to1518Octets Counter,
etherStatsOwner OwnerString,
etherStatsStatus EntryStatus
}
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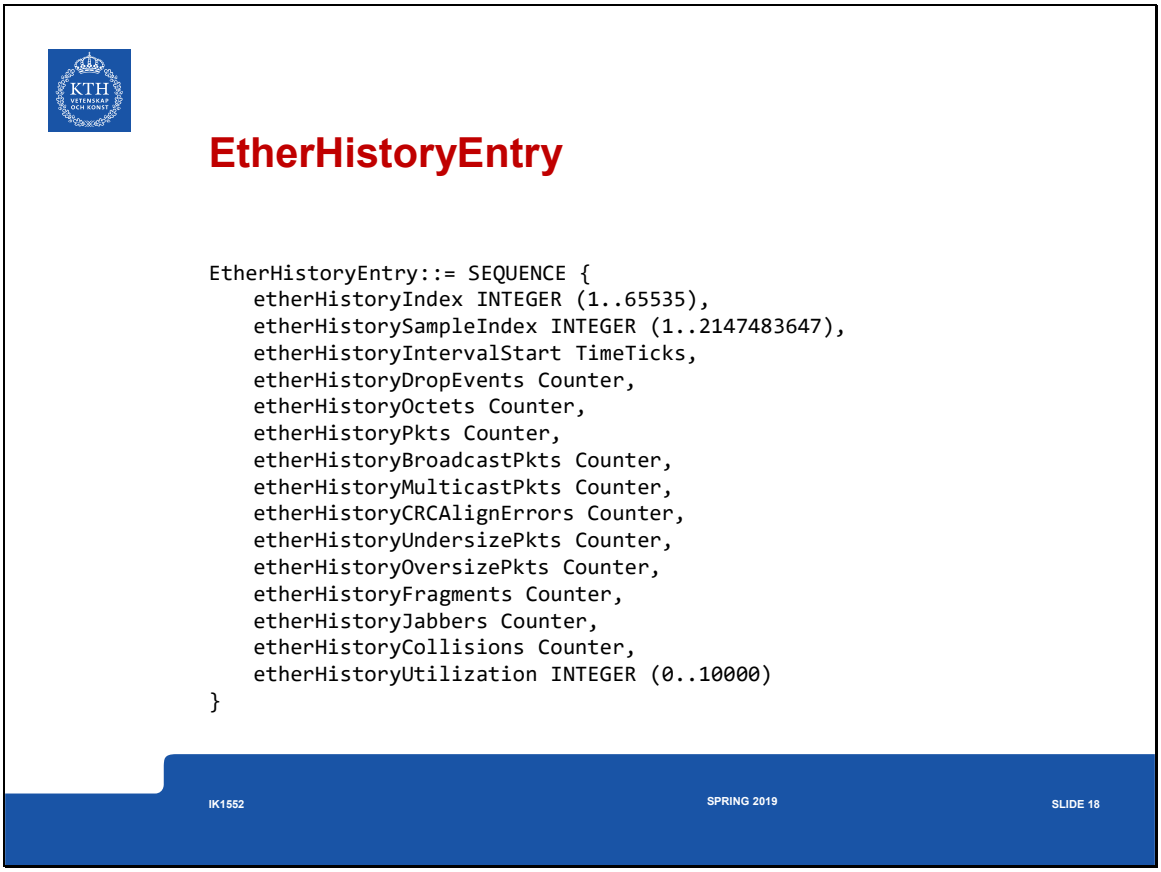
Slide 18


EtherHistoryEntry
EtherHistoryEntry::= SEQUENCE {
etherHistoryIndex INTEGER (1..65535),
etherHistorySampleIndex INTEGER (1..2147483647),
etherHistoryIntervalStart TimeTicks,
etherHistoryDropEvents Counter,
etherHistoryOctets Counter,
etherHistoryPkts Counter,
etherHistoryBroadcastPkts Counter,
etherHistoryMulticastPkts Counter,
etherHistoryCRCAlignErrors Counter,
etherHistoryUndersizePkts Counter,
etherHistoryOversizePkts Counter,
etherHistoryFragments Counter,
etherHistoryJabbers Counter,
etherHistoryCollisions Counter,
etherHistoryUtilization INTEGER (0..10000)
}
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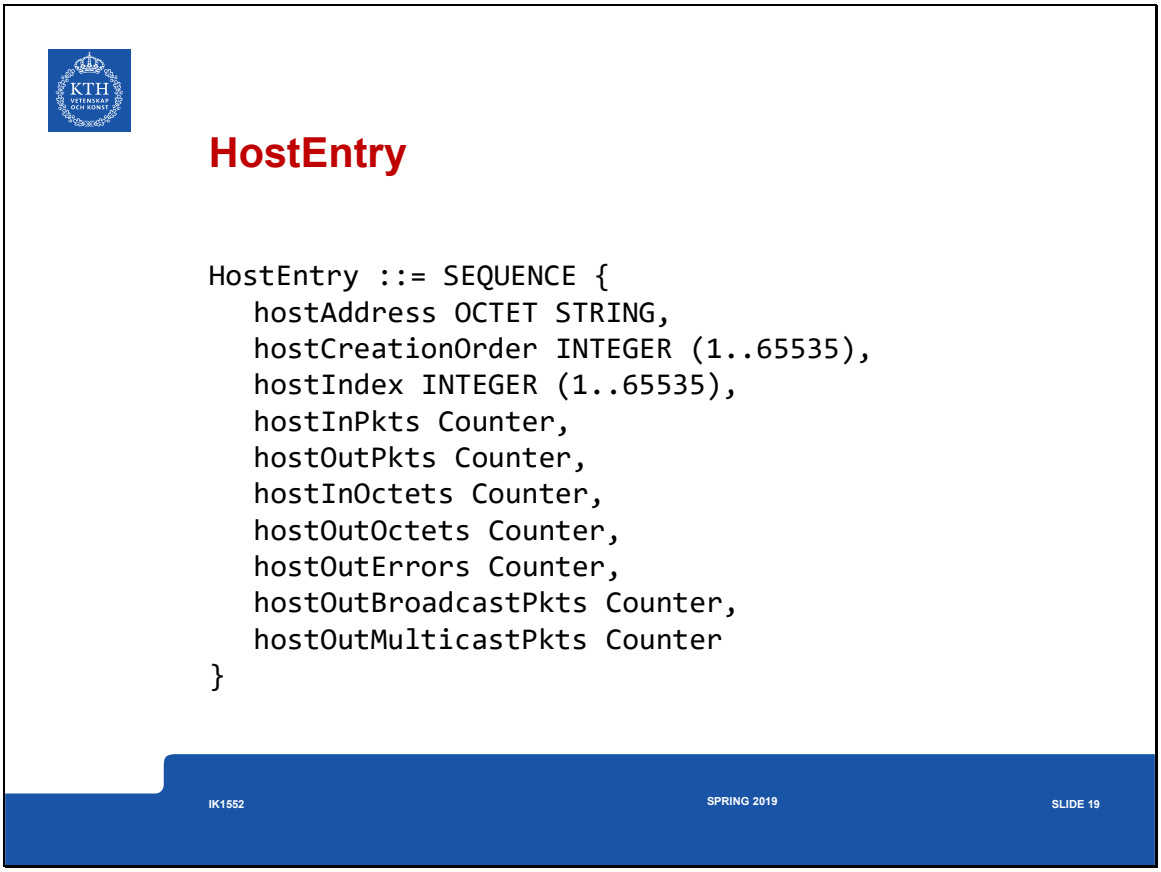
Slide 19


HostEntry
HostEntry ::= SEQUENCE {
hostAddress OCTET STRING,
hostCreationOrder INTEGER (1..65535),
hostIndex INTEGER (1..65535),
hostInPkts Counter,
hostOutPkts Counter,
hostInOctets Counter,
hostOutOctets Counter,
hostOutErrors Counter,
hostOutBroadcastPkts Counter,
hostOutMulticastPkts Counter
}
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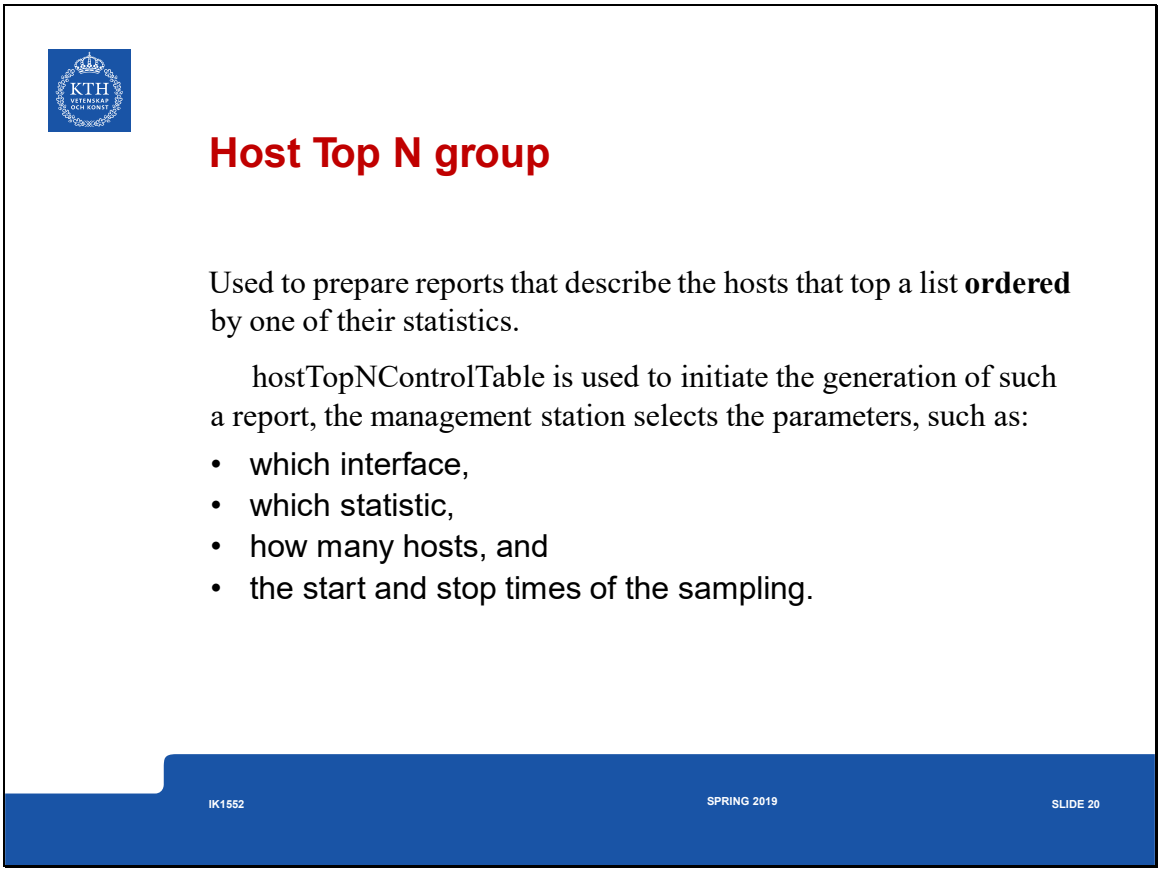
Slide 20


Host Top N group
Used to prepare reports that describe the hosts that top a list ordered by one of their statistics.
hostTopNControlTable is used to initiate the generation of such a report, the management station selects the parameters, such as:
• which interface,
• which statistic,
• how many hosts, and
• the start and stop times of the sampling.
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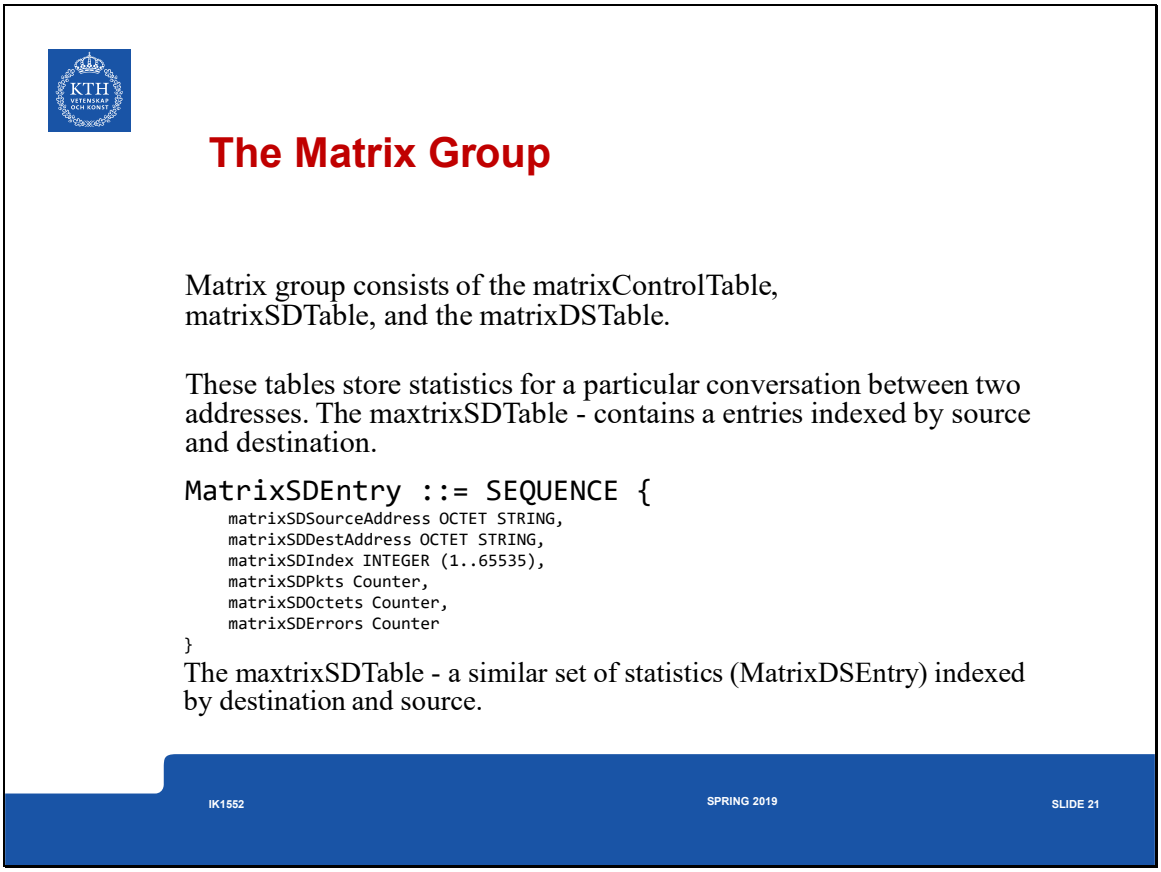

The Matrix Group

Matrix group consists of the matrixControlTable, matrixSDTable, and the matrixDSTable.

These tables store statistics for a particular conversation between two addresses. The maxtrixSDTable - contains a entries indexed by source and destination.

```
MatrixSDEntry ::= SEQUENCE {
    matrixSDSourceAddress OCTET STRING,
    matrixSDDestAddress OCTET STRING,
    matrixSDIndex INTEGER (1..65535),
    matrixSDPkts Counter,
    matrixSDOctets Counter,
    matrixSDErrors Counter
}
```

The maxtrixSDTable - a similar set of statistics (MatrixDSEntry) indexed by destination and source.

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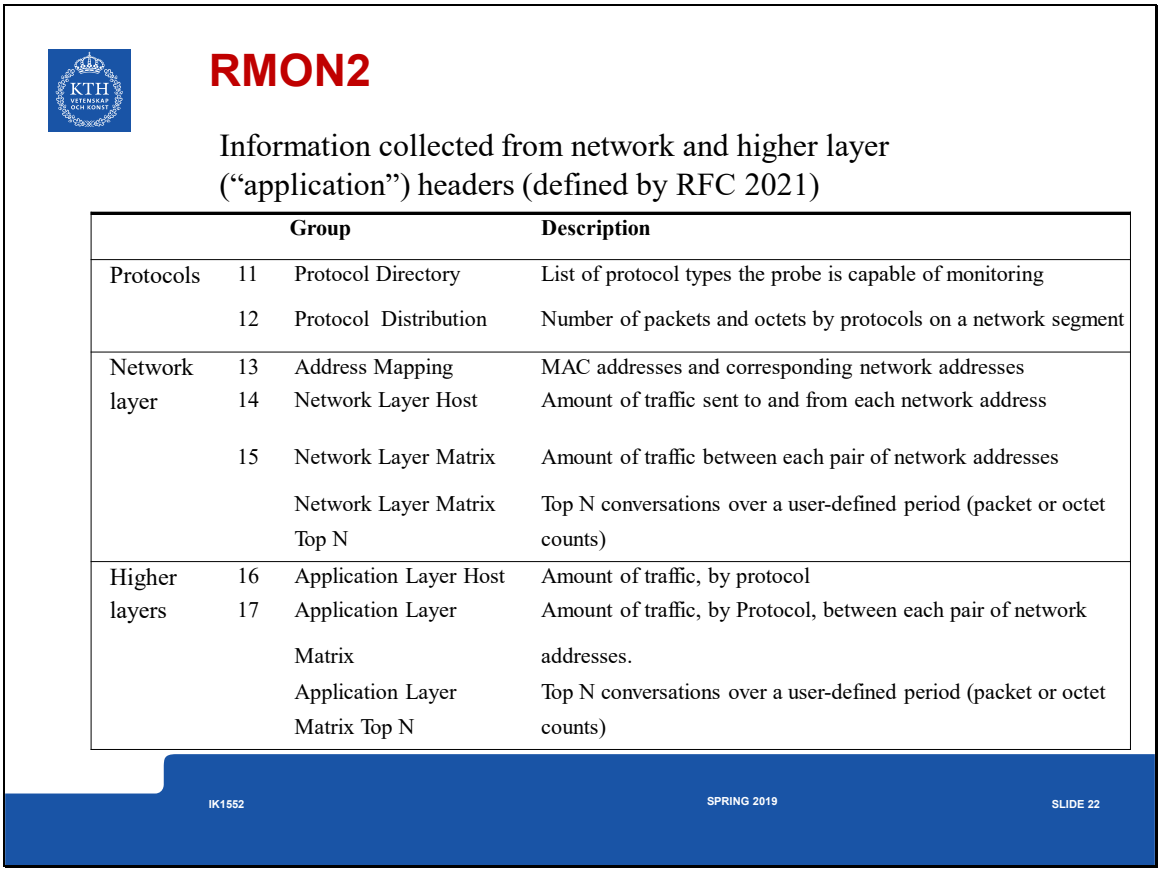

S. Waldbusser, 'Remote Network Monitoring Management Information Base Version 2 using SMIv2', *Internet Request for Comments*, vol. RFC 2021 (Proposed Standard), January 1997, Available at http://www.rfc-editor.org/rfc/rfc2021.txt

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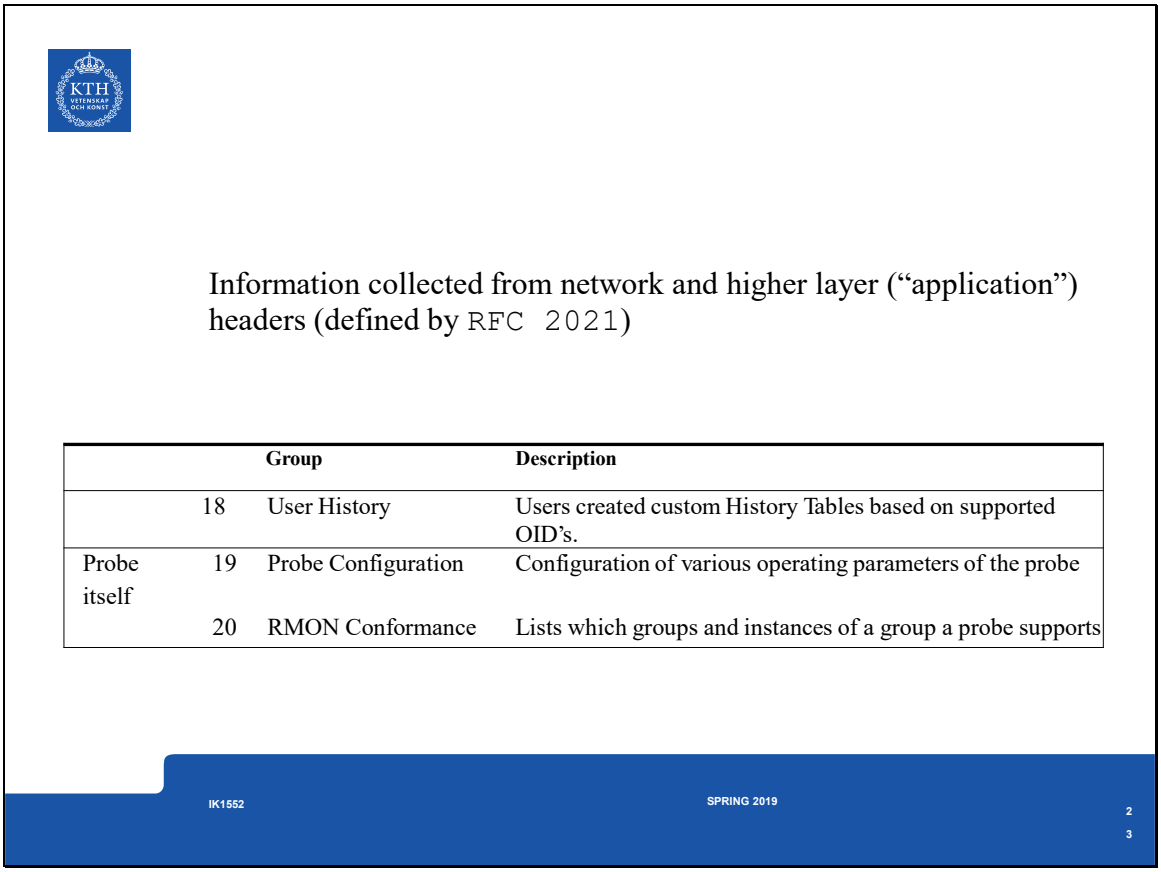

Information collected from network and higher layer (“application”) headers (defined by RFC 2021)

		Group	Description
	18	User History	Users created custom History Tables based on supported OID’s.
Probe itself	19	Probe Configuration	Configuration of various operating parameters of the probe
	20	RMON Conformance	Lists which groups and instances of a group a probe supports

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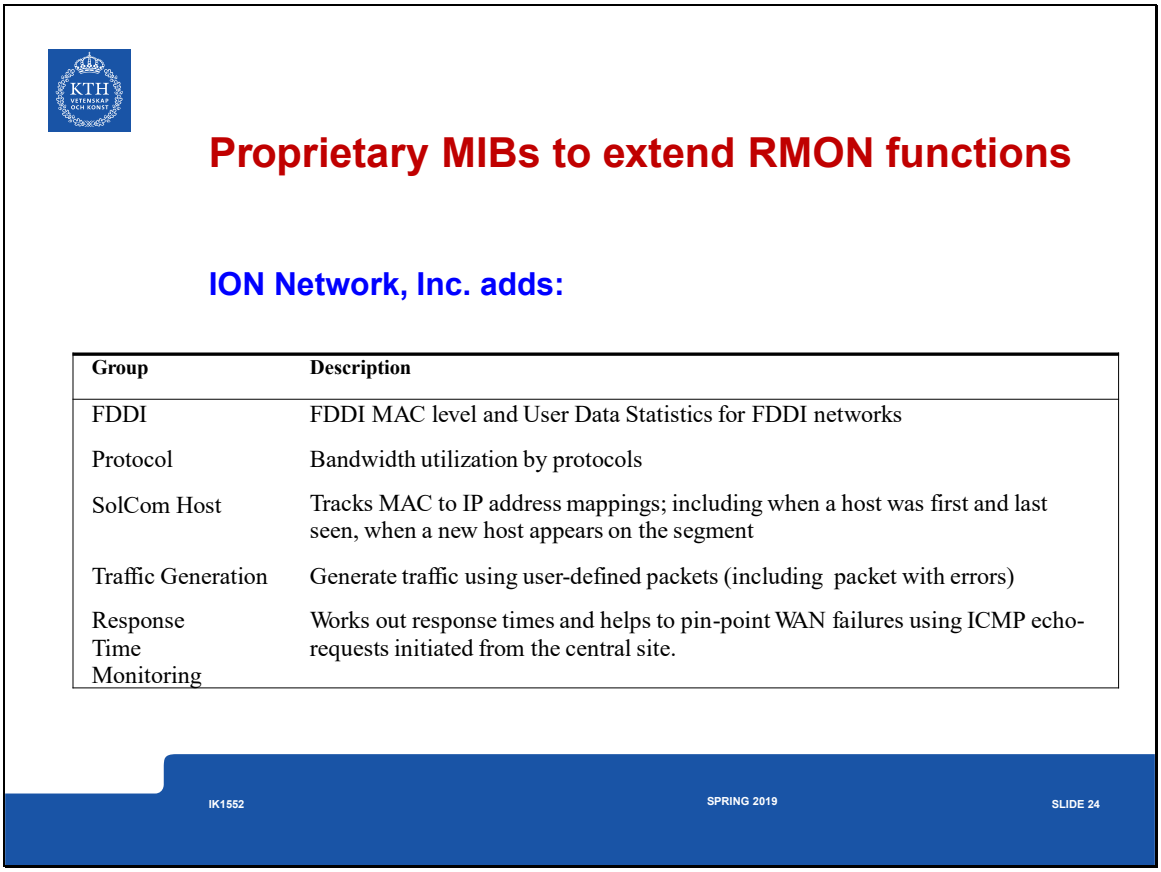
S. Waldbusser, ‘Remote Network Monitoring Management Information Base Version 2 using SMIv2’, *Internet Request for Comments*, vol. RFC 2021 (Proposed Standard), January 1997, Available at http://www.rfc-editor.org/rfc/rfc2021.txt.

S. Waldbusser, ‘Remote Network Monitoring Management Information Base for High Capacity Networks’, *Internet Request for Comments*, vol. RFC 3273 (Proposed Standard), July 2002, Available at http://www.rfc-editor.org/rfc/rfc3273.txt.

E. Stephan and J. Palet, ‘Remote Network Monitoring (RMON) Protocol Identifiers for IPv6 and Multi Protocol Label Switching (MPLS)’, *Internet Request for Comments*, vol. RFC 3919 (Informational), October 2004, Available at http://www.rfc-editor.org/rfc/rfc3919.txt

S. Waldbusser, ‘Remote Network Monitoring Management Information Base Version 2’, *Internet Request for Comments*, vol. RFC 4502 (Draft Standard), May 2006, Available at http://www.rfc-editor.org/rfc/rfc4502.txt

Slide 24

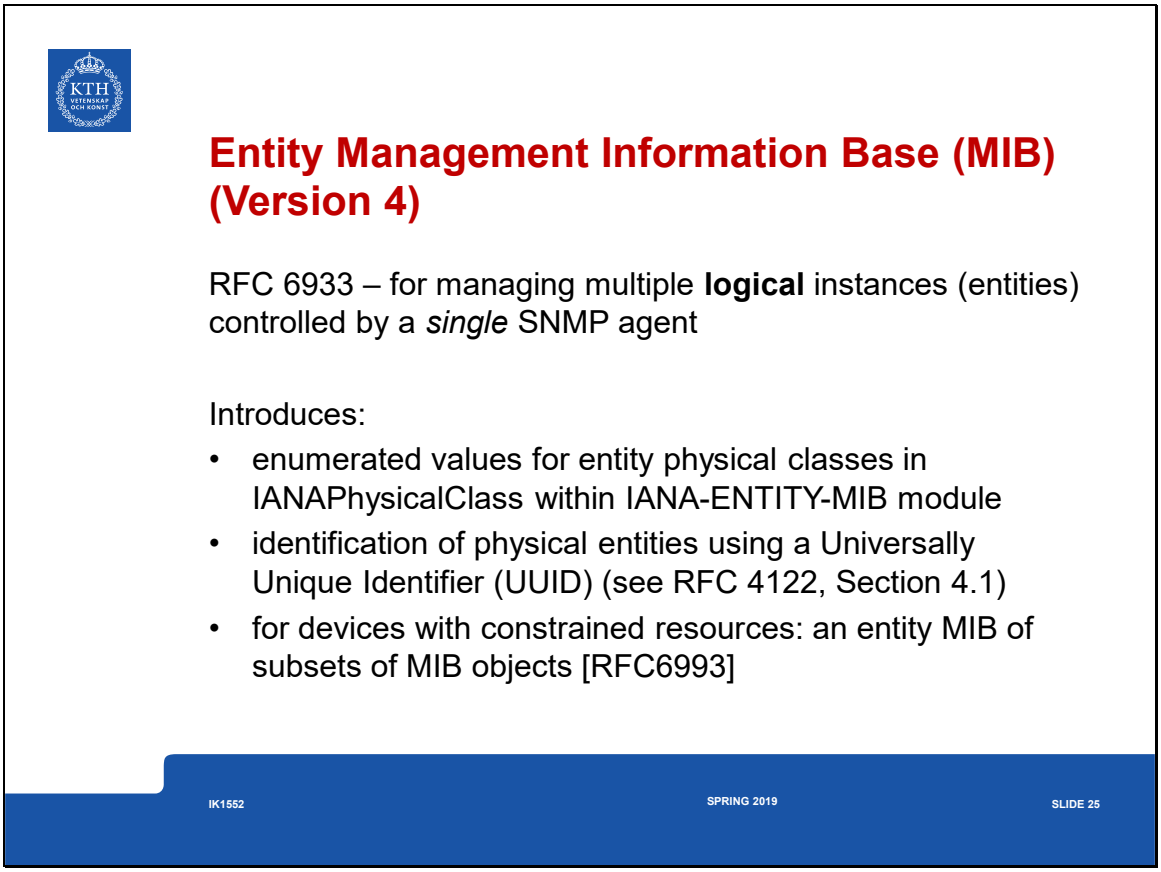


Proprietary MIBs to extend RMON functions

ION Network, Inc. adds:

Group	Description
FDDI	FDDI MAC level and User Data Statistics for FDDI networks
Protocol	Bandwidth utilization by protocols
SolCom Host	Tracks MAC to IP address mappings; including when a host was first and last seen, when a new host appears on the segment
Traffic Generation	Generate traffic using user-defined packets (including packet with errors)
Response Time Monitoring	Works out response times and helps to pin-point WAN failures using ICMP echo-requests initiated from the central site.

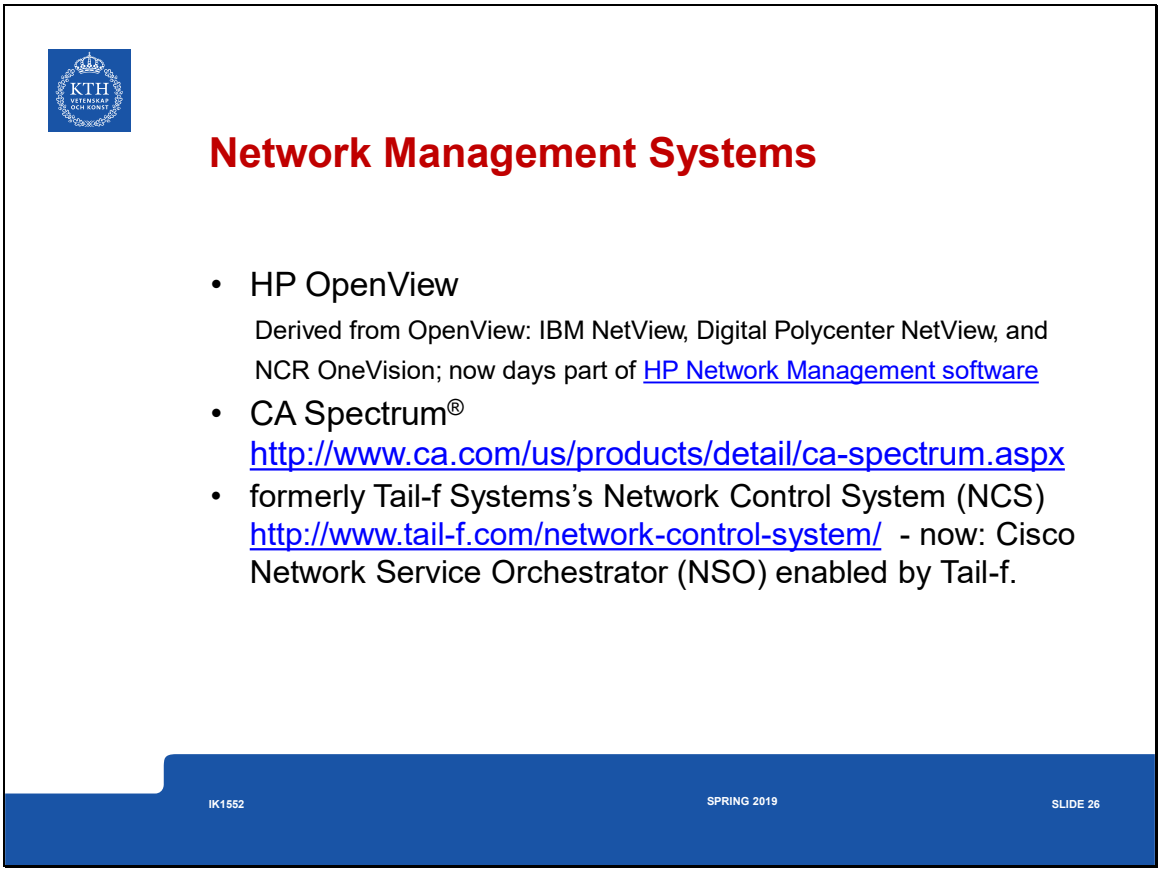
Slide 25



[RFC6993] A. Bierman, D. Romascanu, J. Quittek, and M. Chandramouli, 'Entity MIB (Version 4)', *Internet Request for Comments*, vol. RFC 6933 (Proposed Standard), May 2013 [Online]. Available: http://www.rfc-editor.org/rfc/rfc6933.txt

[RFC4122] P. Leach, M. Mealling, and R. Salz, 'A Universally Unique IDentifier (UUID) URN Namespace', *Internet Request for Comments*, vol. RFC 4122 (Proposed Standard), Jul. 2005 [Online]. Available: http://www.rfc-editor.org/rfc/rfc4122.txt

Slide 26


Network Management Systems
• HP OpenView
Derived from OpenView: IBM NetView, Digital Polycenter NetView, and NCR OneVision; now days part of HP Network Management software
• CA Spectrum®
http://www.ca.com/us/products/detail/ca-spectrum.aspx
• formerly Tail-f Systems's Network Control System (NCS) http://www.tail-f.com/network-control-system/ - now: Cisco Network Service Orchestrator (NSO) enabled by Tail-f.
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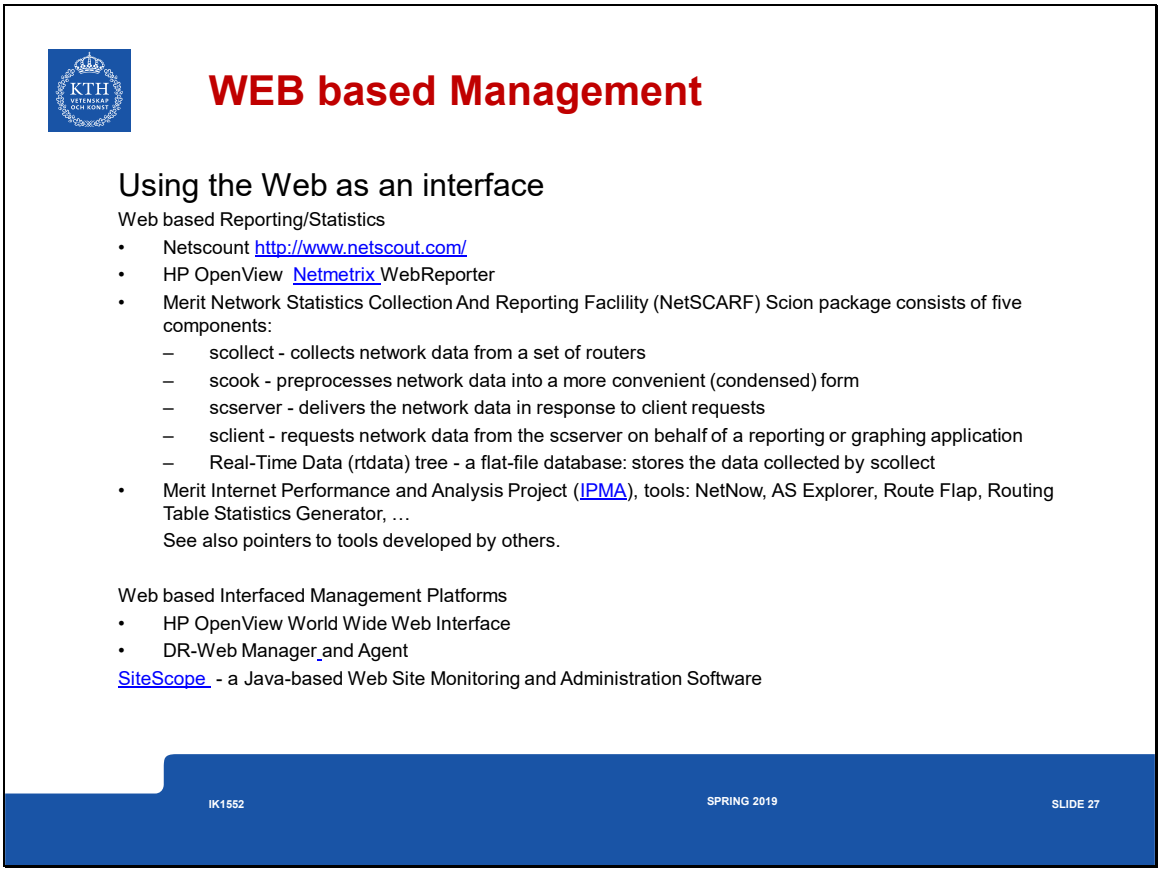

“Welcome to the NetSCARF Workshop”, 9 February 1997,
http://www.academ.com/nanog/feb1997/NetSCARF/

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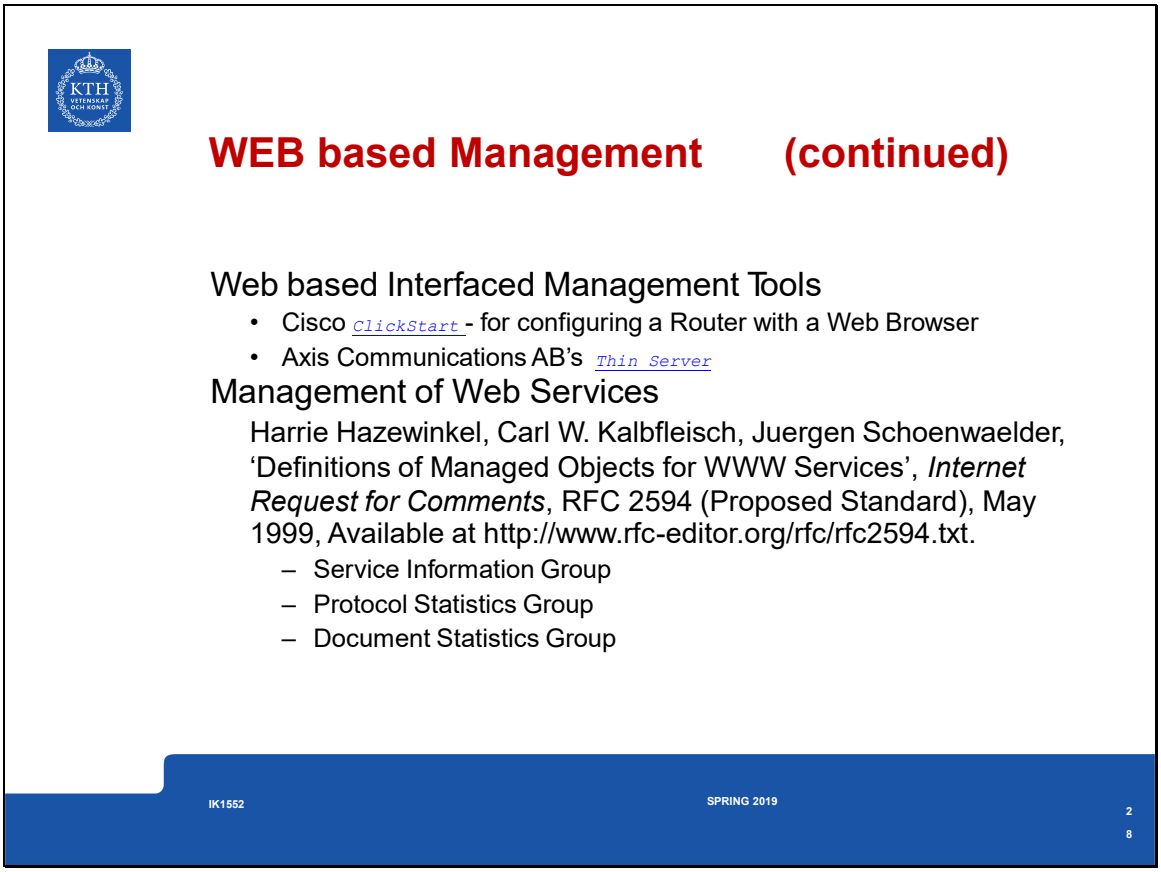
WEB based Management (continued)
Web based Interfaced Management Tools
• Cisco ClickStart - for configuring a Router with a Web Browser
• Axis Communications AB's Thin Server
Management of Web Services
Harrie Hazewinkel, Carl W. Kalbfleisch, Juergen Schoenwaelder, 'Definitions of Managed Objects for WWW Services', Internet Request for Comments, RFC 2594 (Proposed Standard), May 1999, Available at http://www.rfc-editor.org/rfc/rfc2594.txt.
– Service Information Group
– Protocol Statistics Group
– Document Statistics Group
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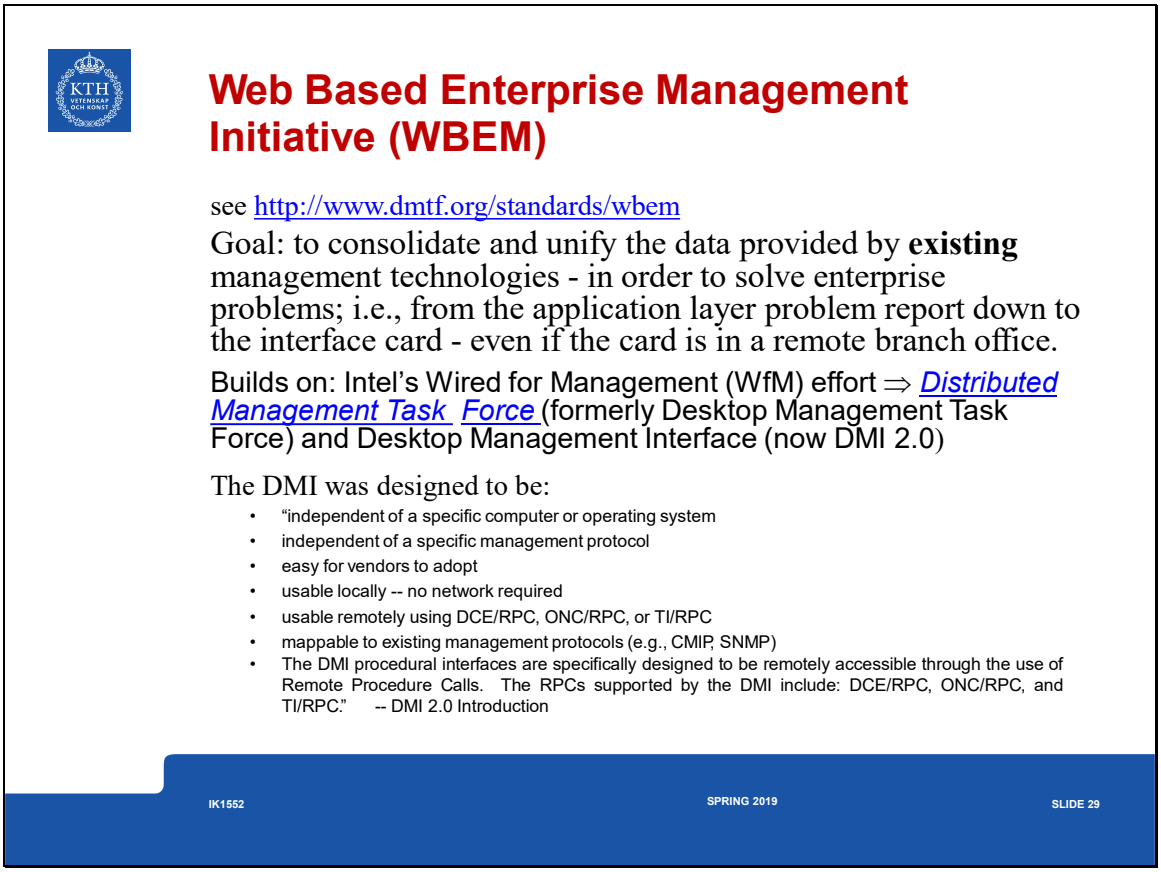
Web Based Enterprise Management Initiative (WBEM)
see http://www.dmtf.org/standards/wbem
Goal: to consolidate and unify the data provided by existing management technologies - in order to solve enterprise problems; i.e., from the application layer problem report down to the interface card - even if the card is in a remote branch office.
Builds on: Intel's Wired for Management (WfM) effort ⇒ Distributed Management Task Force (formerly Desktop Management Task Force) and Desktop Management Interface (now DMI 2.0)
The DMI was designed to be:
"independent of a specific computer or operating system
independent of a specific management protocol
easy for vendors to adopt
usable locally -- no network required
usable remotely using DCE/RPC, ONC/RPC, or TI/RPC
mappable to existing management protocols (e.g., CMIP, SNMP)
The DMI procedural interfaces are specifically designed to be remotely accessible through the use of Remote Procedure Calls. The RPCs supported by the DMI include: DCE/RPC, ONC/RPC, and TI/RPC." -- DMI 2.0 Introduction
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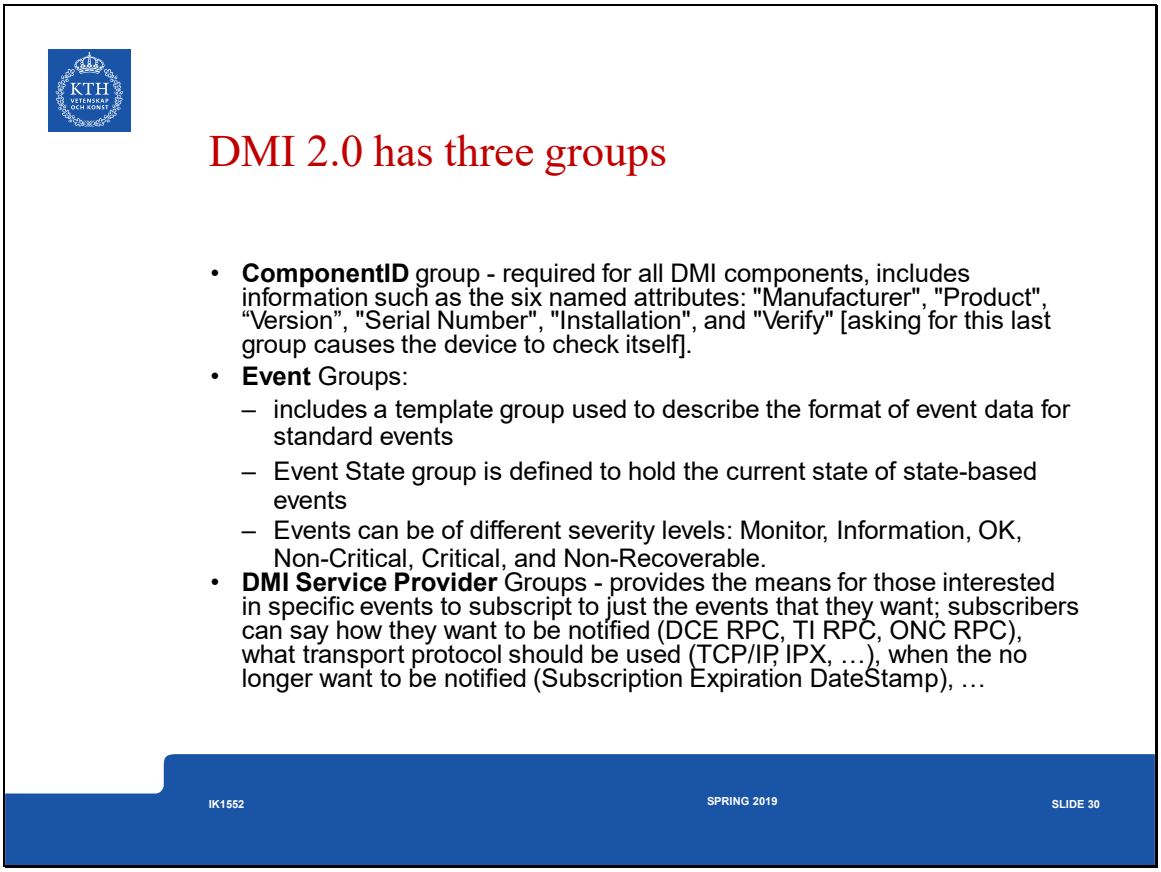
DMI 2.0 has three groups
• ComponentID group - required for all DMI components, includes information such as the six named attributes: "Manufacturer", "Product", “Version”, "Serial Number", "Installation", and "Verify" [asking for this last group causes the device to check itself].
• Event Groups:
– includes a template group used to describe the format of event data for standard events
– Event State group is defined to hold the current state of state-based events
– Events can be of different severity levels: Monitor, Information, OK, Non-Critical, Critical, and Non-Recoverable.
• DMI Service Provider Groups - provides the means for those interested in specific events to subscript to just the events that they want; subscribers can say how they want to be notified (DCE RPC, TI RPC, ONC RPC), what transport protocol should be used (TCP/IP, IPX, …), when the no longer want to be notified (Subscription Expiration DateStamp), …
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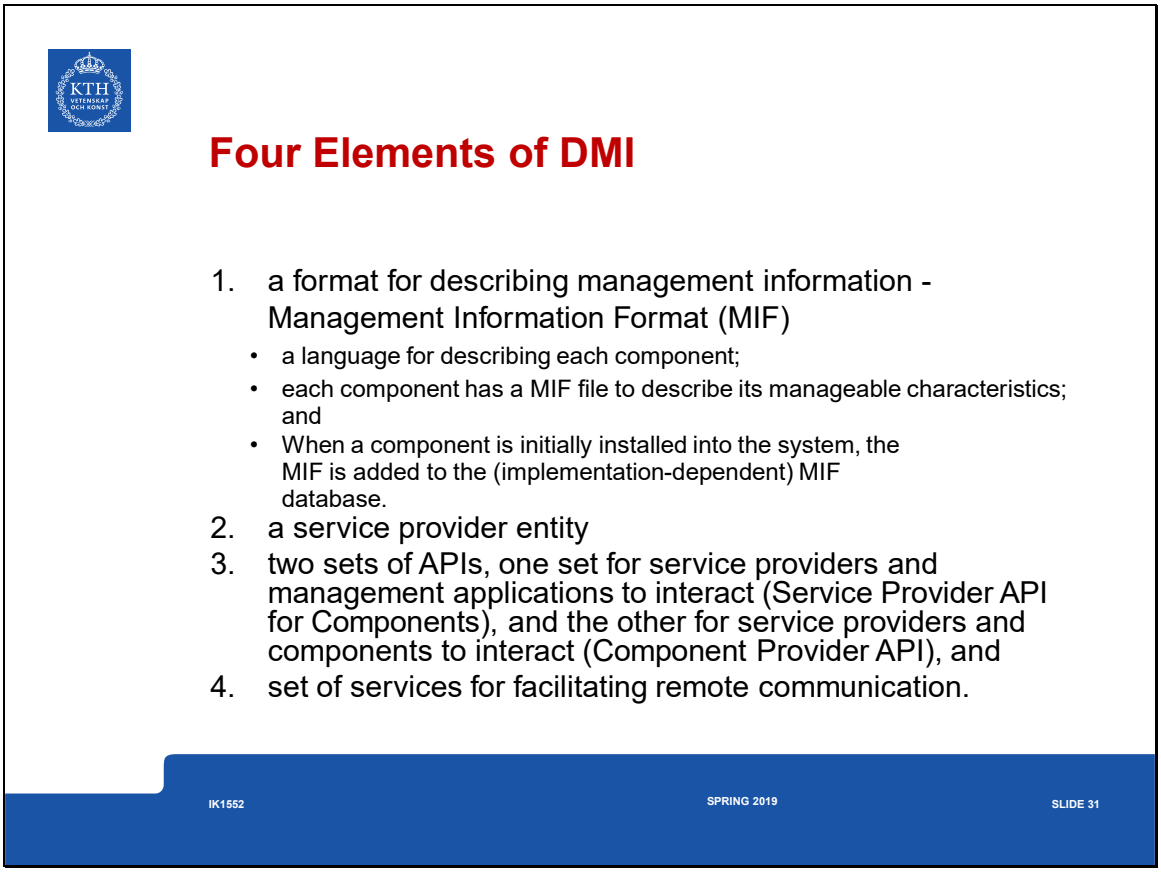
Four Elements of DMI
1. a format for describing management information - Management Information Format (MIF)
• a language for describing each component;
• each component has a MIF file to describe its manageable characteristics; and
• When a component is initially installed into the system, the MIF is added to the (implementation-dependent) MIF database.
2. a service provider entity
3. two sets of APIs, one set for service providers and management applications to interact (Service Provider API for Components), and the other for service providers and components to interact (Component Provider API), and
4. set of services for facilitating remote communication.
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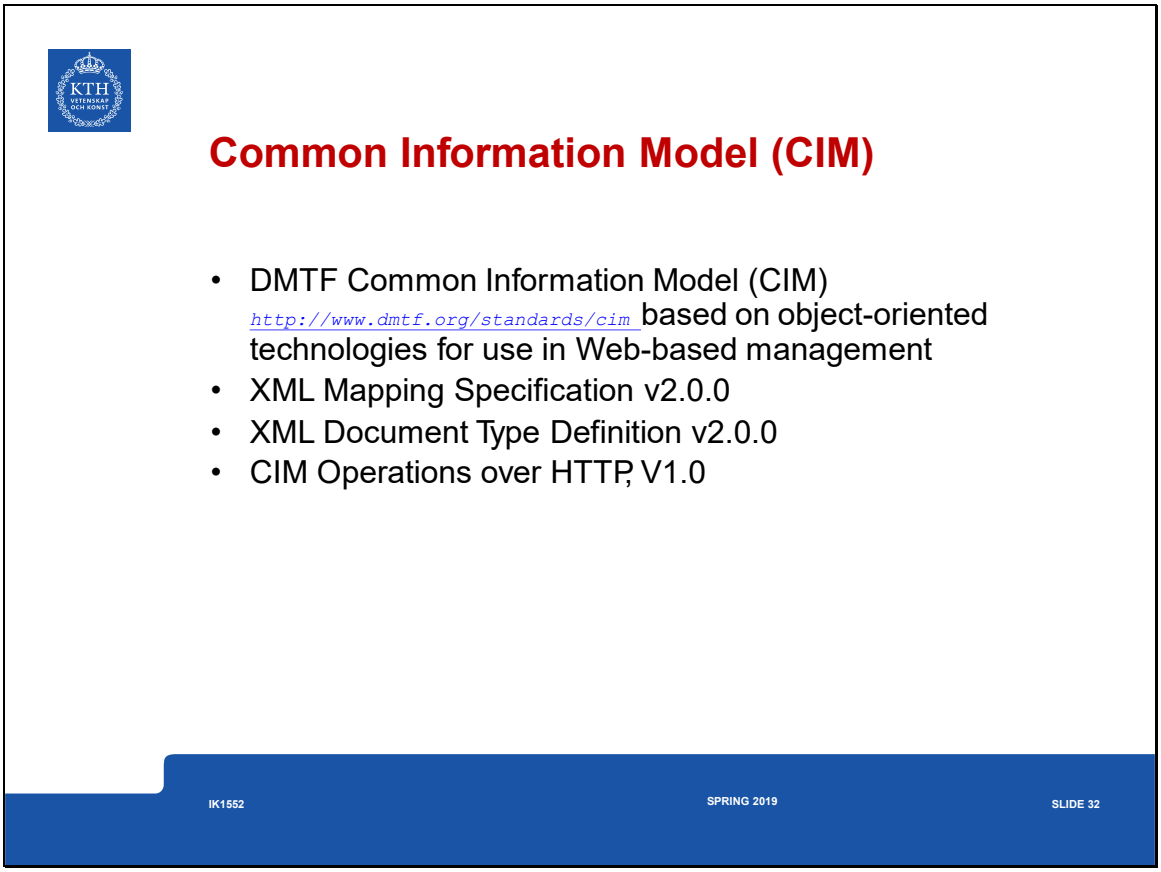
Common Information Model (CIM)
• DMTF Common Information Model (CIM) http://www.dmtf.org/standards/cim based on object-oriented technologies for use in Web-based management
• XML Mapping Specification v2.0.0
• XML Document Type Definition v2.0.0
• CIM Operations over HTTP, V1.0
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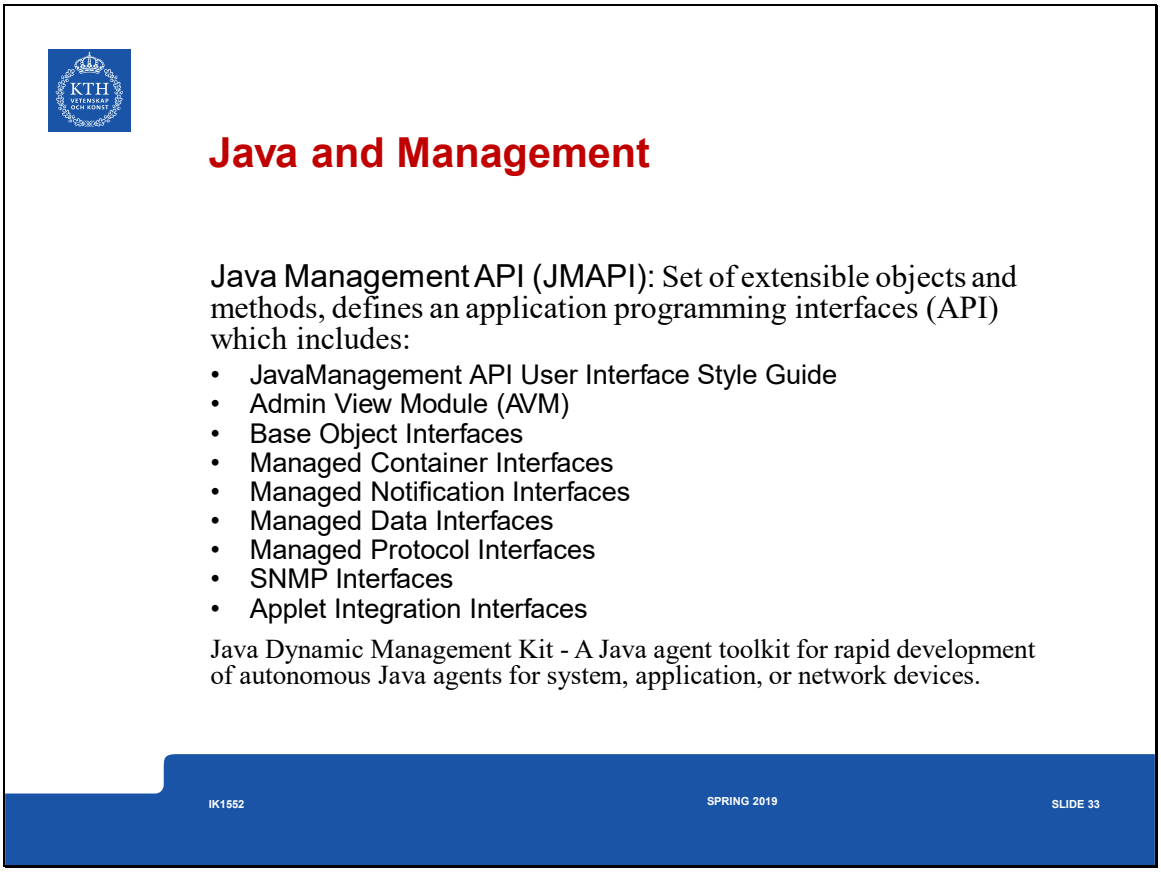
Java and Management
Java Management API (JMAPI): Set of extensible objects and methods, defines an application programming interfaces (API) which includes:
• JavaManagement API User Interface Style Guide
• Admin View Module (AVM)
• Base Object Interfaces
• Managed Container Interfaces
• Managed Notification Interfaces
• Managed Data Interfaces
• Managed Protocol Interfaces
• SNMP Interfaces
• Applet Integration Interfaces
Java Dynamic Management Kit - A Java agent toolkit for rapid development of autonomous Java agents for system, application, or network devices.
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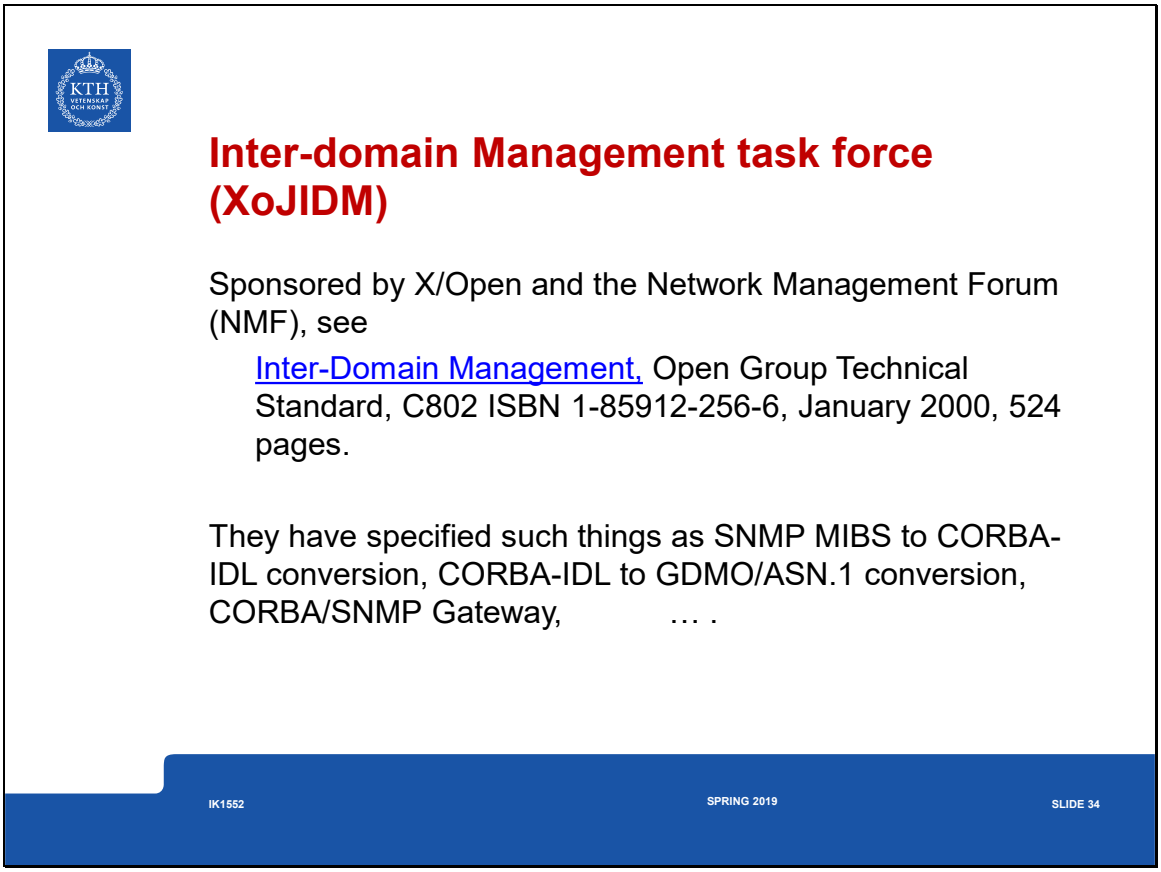

Subrata Mazumdar, Inter-Domain Management between CORBA and SNMP : WEB-based Management - CORBA/SNMP Gateway Approach,
Presented at DSOM'96, L'Aquila, Italy, October 28-30, 1996
http://www.dca.fee.unicamp.br/~eleri/inf561/02/CORBASnmpExt.pdf

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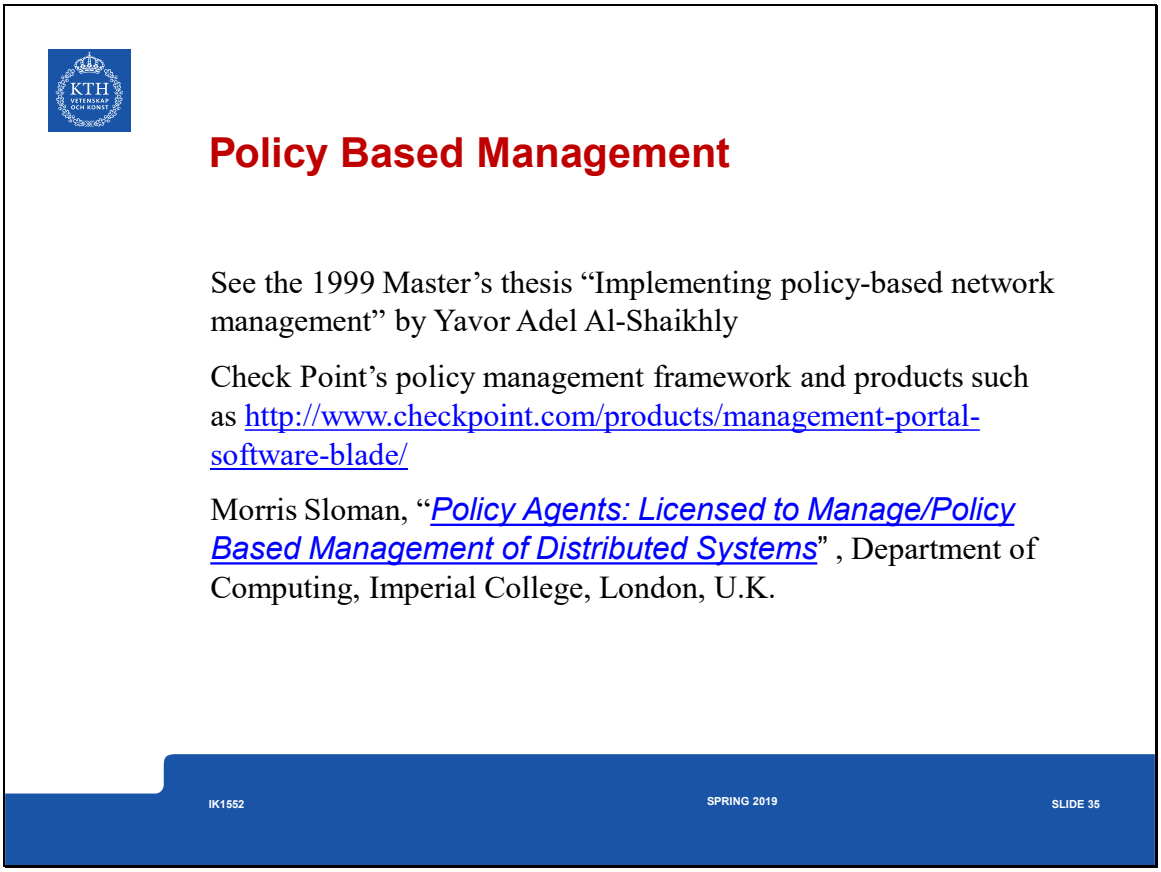

Yavor Adel Al-Sheikhly, 'Implementing policy-based network management', Master's thesis, KTH Royal Institute of Technology, Teleinformatics, Stockholm, Sweden, 1999 [Online]. Available: http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-95440

Morris Sloman, "*Policy Agents: Licensed to Manage/Policy Based Management of Distributed Systems*"
*http://www.doc.ic.ac.uk/~mss/**policy_agents**.pdf*

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Managing networks – the cutting edge

To deal with network functions virtualization (NFV), software-defined networking (SDN), and carrier cloud architectures, ~50 network operators and cloud providers have introduced:
Open Network Automation Platform - https://www.onap.org/

Georgios P. Katsikas, Tom Barbette, Dejan Kostic, Rebecca Steinert, and Gerald Q. Maguire Jr., 'Metron: NFV Service Chains at the True Speed of the Underlying Hardware', in Proceedings of the 15th USENIX Symposium on Networked Systems Design and Implementation (NSDI), Renton, WA, USA, 2018 [Online]. Available: https://www.usenix.org/conference/nsdi18/presentation/katsikas

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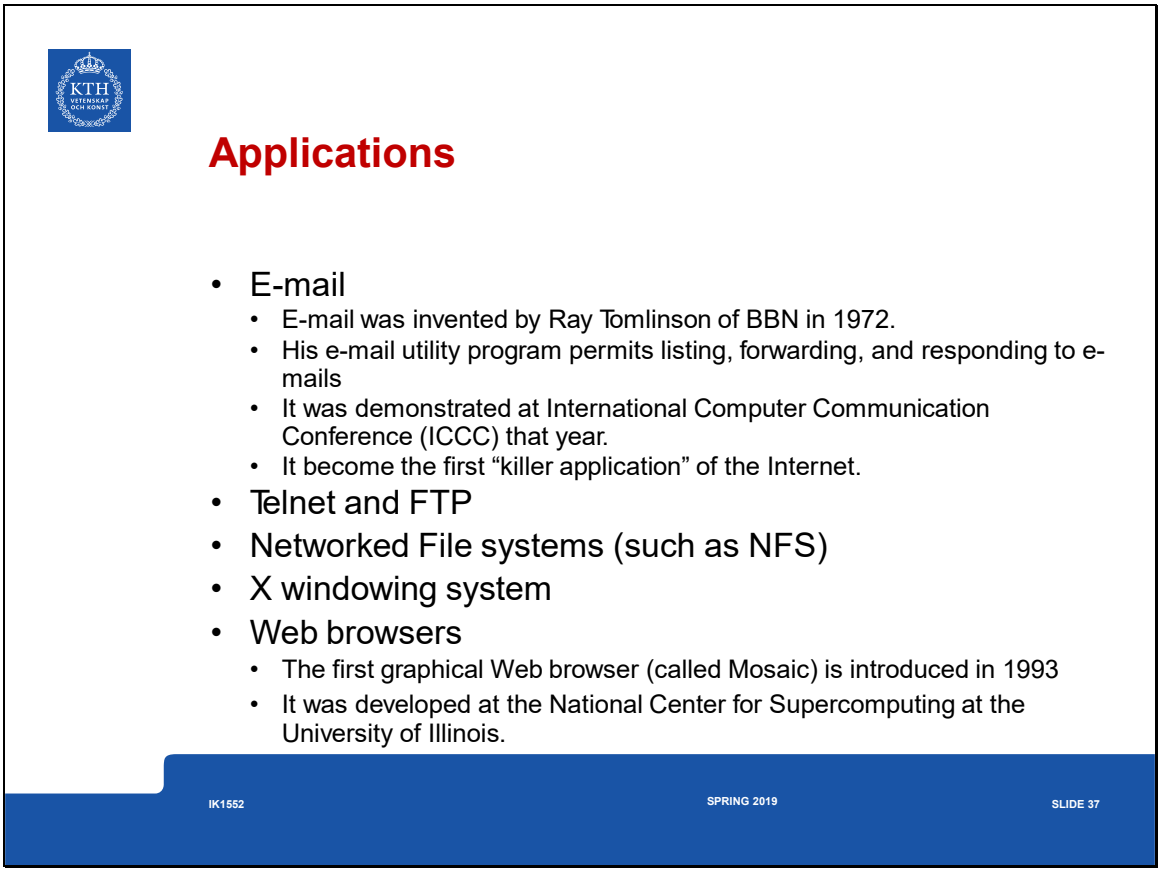
Applications
E-mail
E-mail was invented by Ray Tomlinson of BBN in 1972.
His e-mail utility program permits listing, forwarding, and responding to e-mails
It was demonstrated at International Computer Communication Conference (ICCC) that year.
It become the first “killer application” of the Internet.
Telnet and FTP
Networked File systems (such as NFS)
X windowing system
Web browsers
The first graphical Web browser (called Mosaic) is introduced in 1993
It was developed at the National Center for Supercomputing at the University of Illinois.
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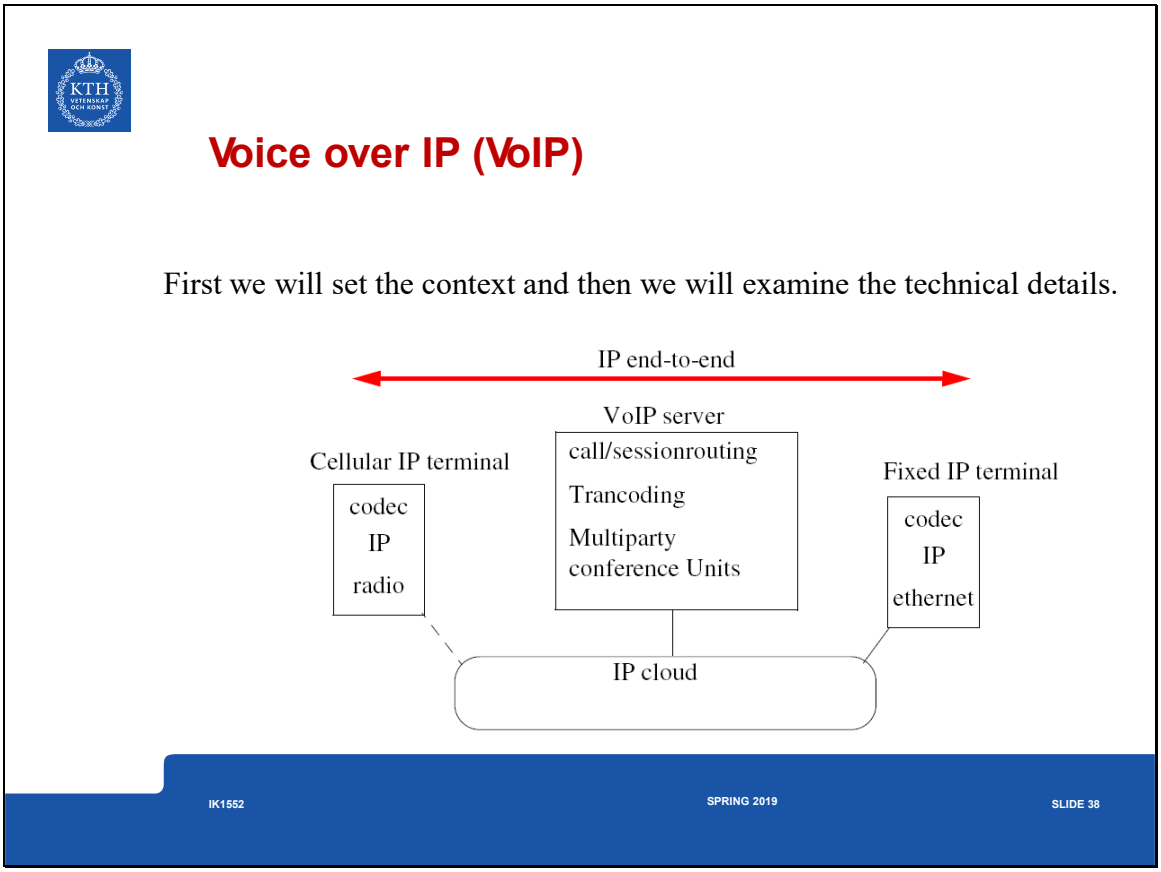
Voice over IP (VoIP)
First we will set the context and then we will examine the technical details.
IP end-to-end
VoIP server
call/sessionrouting
Trancoding
Multiparty conference Units
Cellular IP terminal
codec
IP
radio
Fixed IP terminal
codec
IP
ethernet
IP cloud
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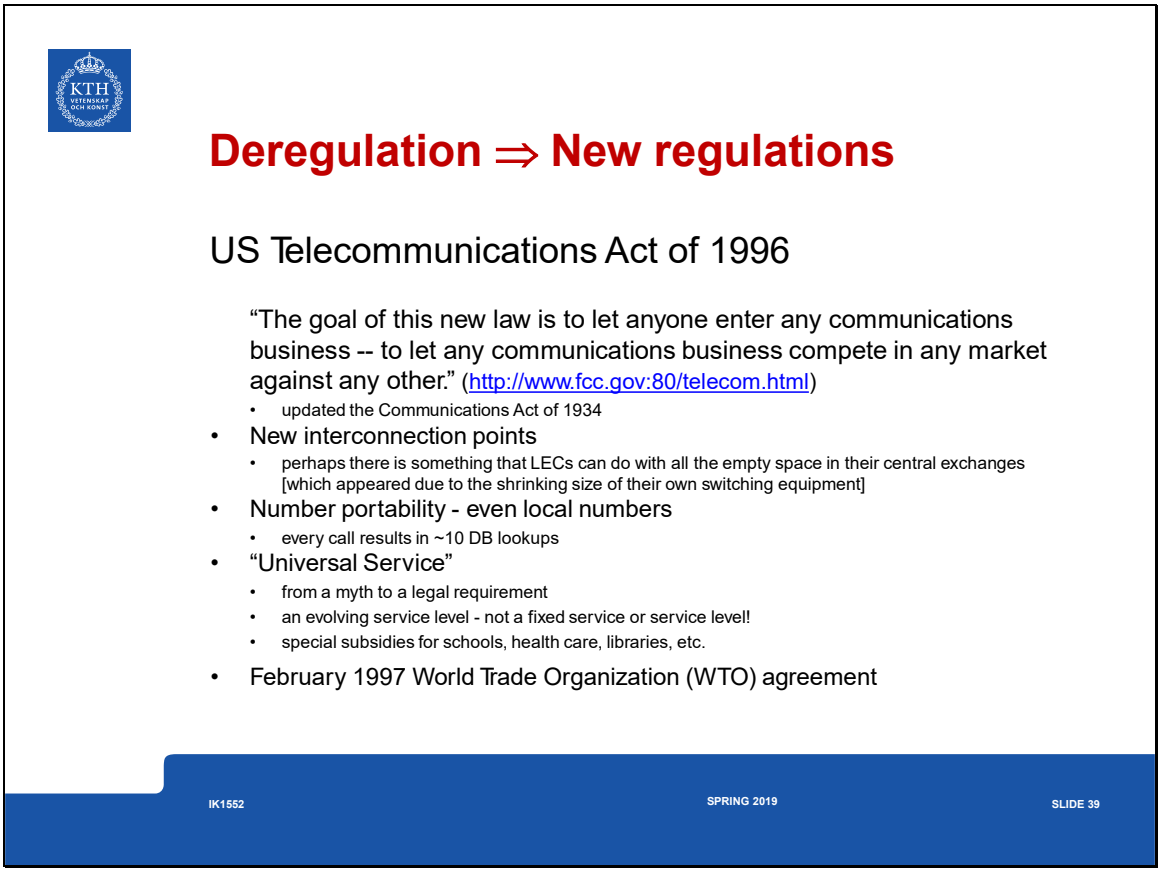

The official citation for the new Act is: Telecommunications Act of 1996, Pub. LA. No. 104-104, 110 Stat. 56 (1996).

For informal background see "WTO negotiations on basic Telecommunications" - http://www.wto.org/wto/services/tel.htm

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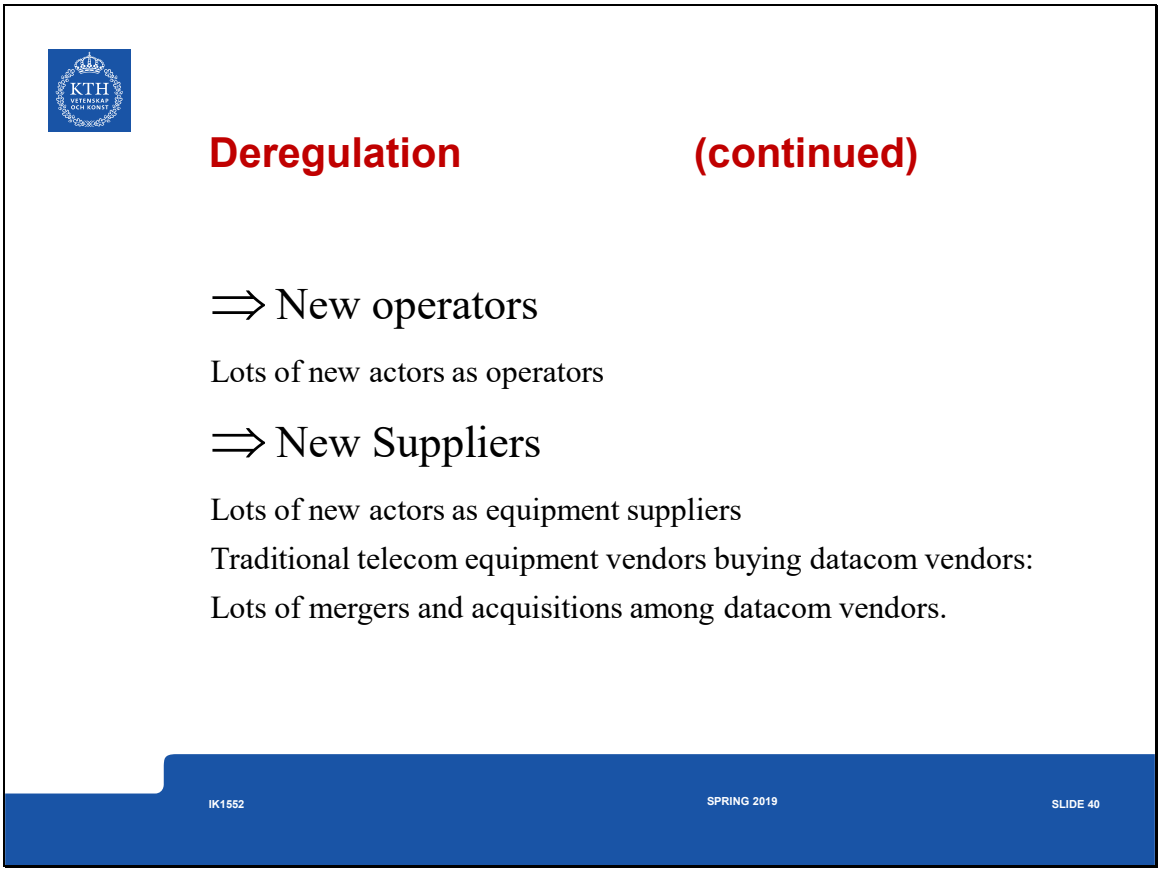
Deregulation (continued)
⇒ New operators
Lots of new actors as operators
⇒ New Suppliers
Lots of new actors as equipment suppliers
Traditional telecom equipment vendors buying datacom vendors:
Lots of mergers and acquisitions among datacom vendors.
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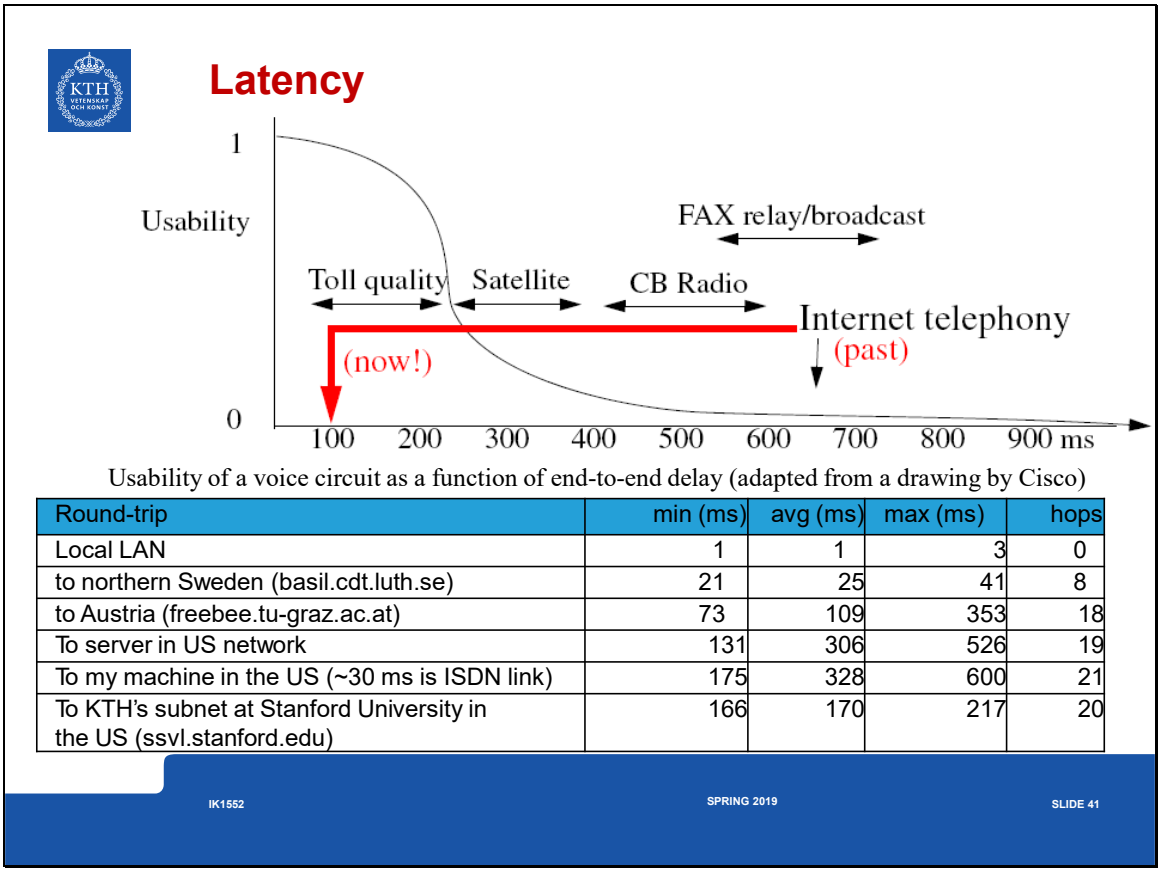

Round-trip	min (ms)	avg (ms)	max (ms)	hops
Local LAN	1	1	3	0
to northern Sweden (basil.cdt.luth.se)	21	25	41	8
to Austria (freebee.tu-graz.ac.at)	73	109	353	18
To server in US network	131	306	526	19
To my machine in the US (~30 ms is ISDN link)	175	328	600	21
To KTH's subnet at Stanford University in the US (ssvl.stanford.edu)	166	170	217	20

Figure is adapted from
http://www.packeteer.com/solutions/voip/sld006.htm

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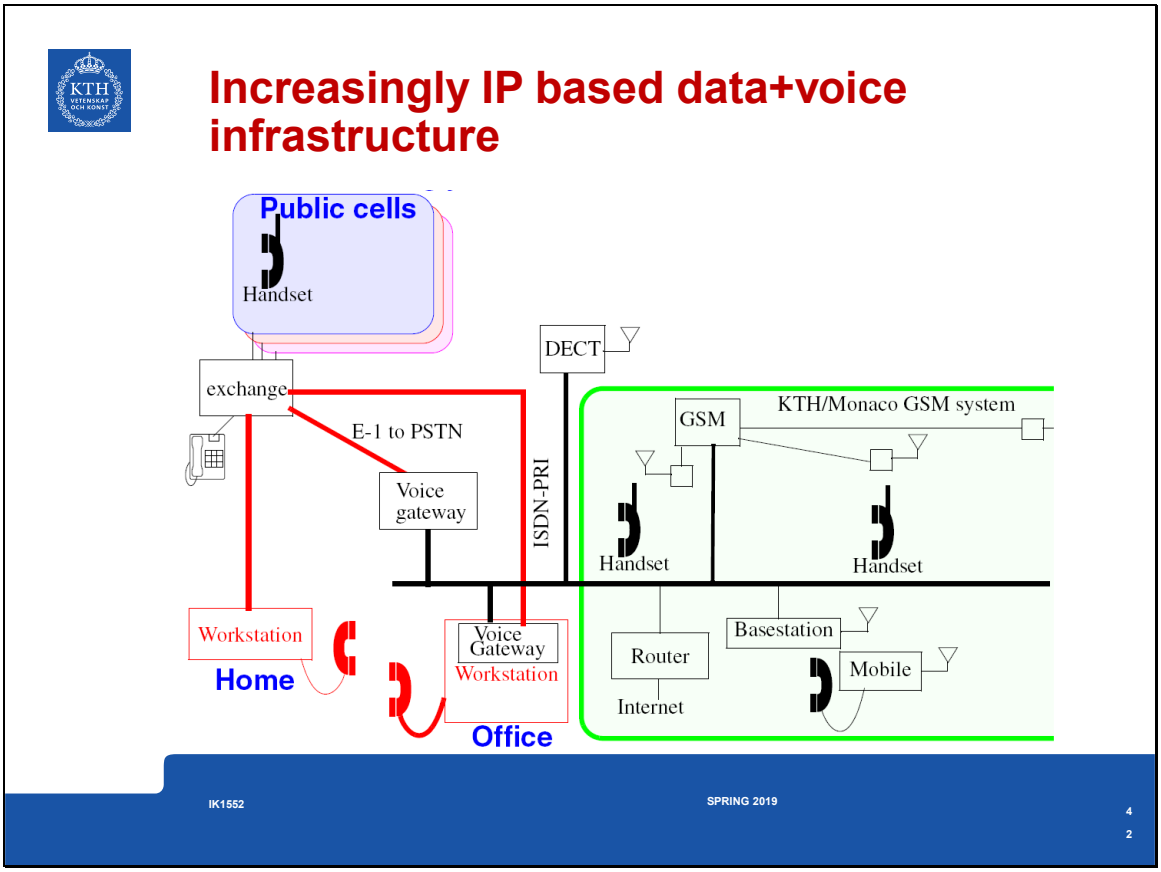
Increasingly IP based data+voice infrastructure
Public cells
Handset
exchange
E-1 to PSTN
Voice gateway
ISDN-PRI
DECT
GSM
KTH/Monaco GSM system
Handset
Handset
Workstation
Home
Voice Gateway
Workstation
Office
Router
Internet
Basestation
Mobile
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2

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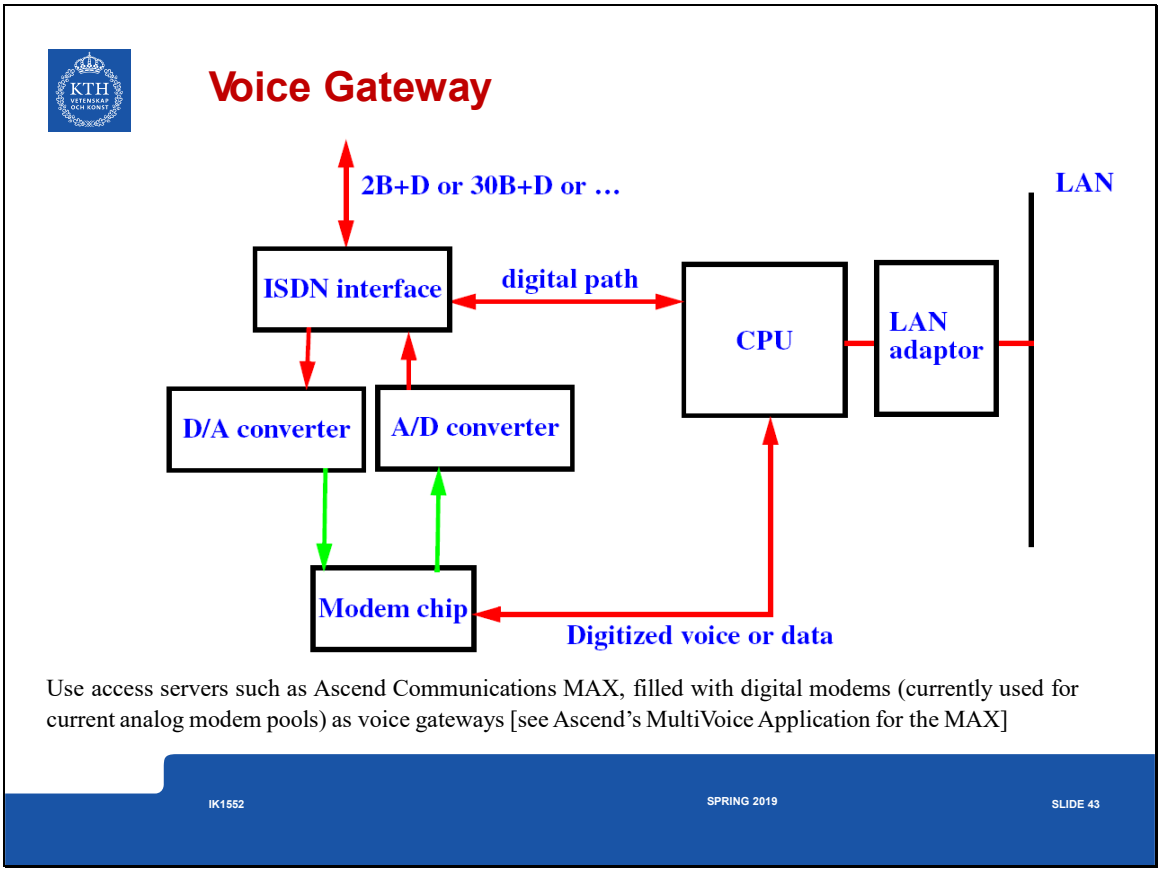
Voice Gateway
2B+D or 30B+D or …
LAN
ISDN interface
digital path
CPU
LAN adaptor
D/A converter
A/D converter
Modem chip
Digitized voice or data
Use access servers such as Ascend Communications MAX, filled with digital modems (currently used for current analog modem pools) as voice gateways [see Ascend's MultiVoice Application for the MAX]
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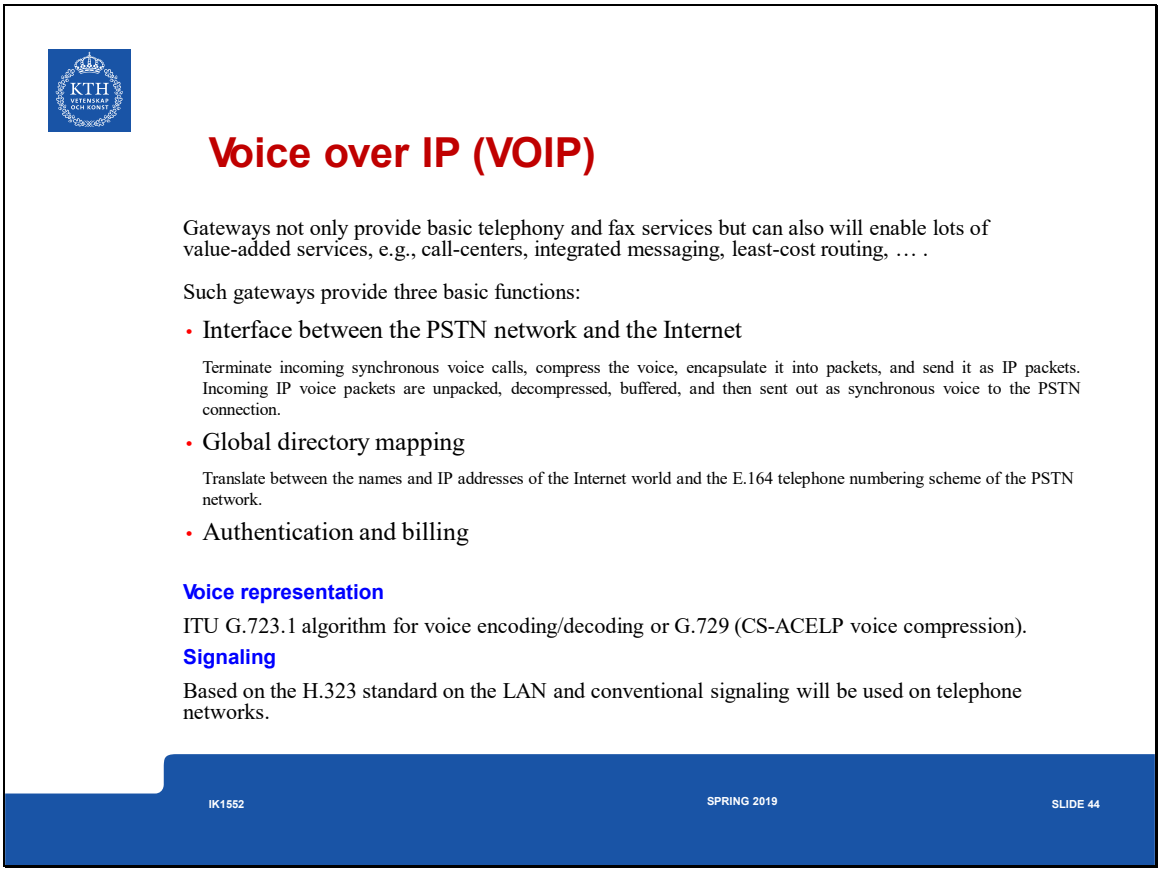
Voice over IP (VOIP)
Gateways not only provide basic telephony and fax services but can also will enable lots of value-added services, e.g., call-centers, integrated messaging, least-cost routing, … .
Such gateways provide three basic functions:
• Interface between the PSTN network and the Internet
Terminate incoming synchronous voice calls, compress the voice, encapsulate it into packets, and send it as IP packets. Incoming IP voice packets are unpacked, decompressed, buffered, and then sent out as synchronous voice to the PSTN connection.
• Global directory mapping
Translate between the names and IP addresses of the Internet world and the E.164 telephone numbering scheme of the PSTN network.
• Authentication and billing
Voice representation
ITU G.723.1 algorithm for voice encoding/decoding or G.729 (CS-ACELP voice compression).
Signaling
Based on the H.323 standard on the LAN and conventional signaling will be used on telephone networks.
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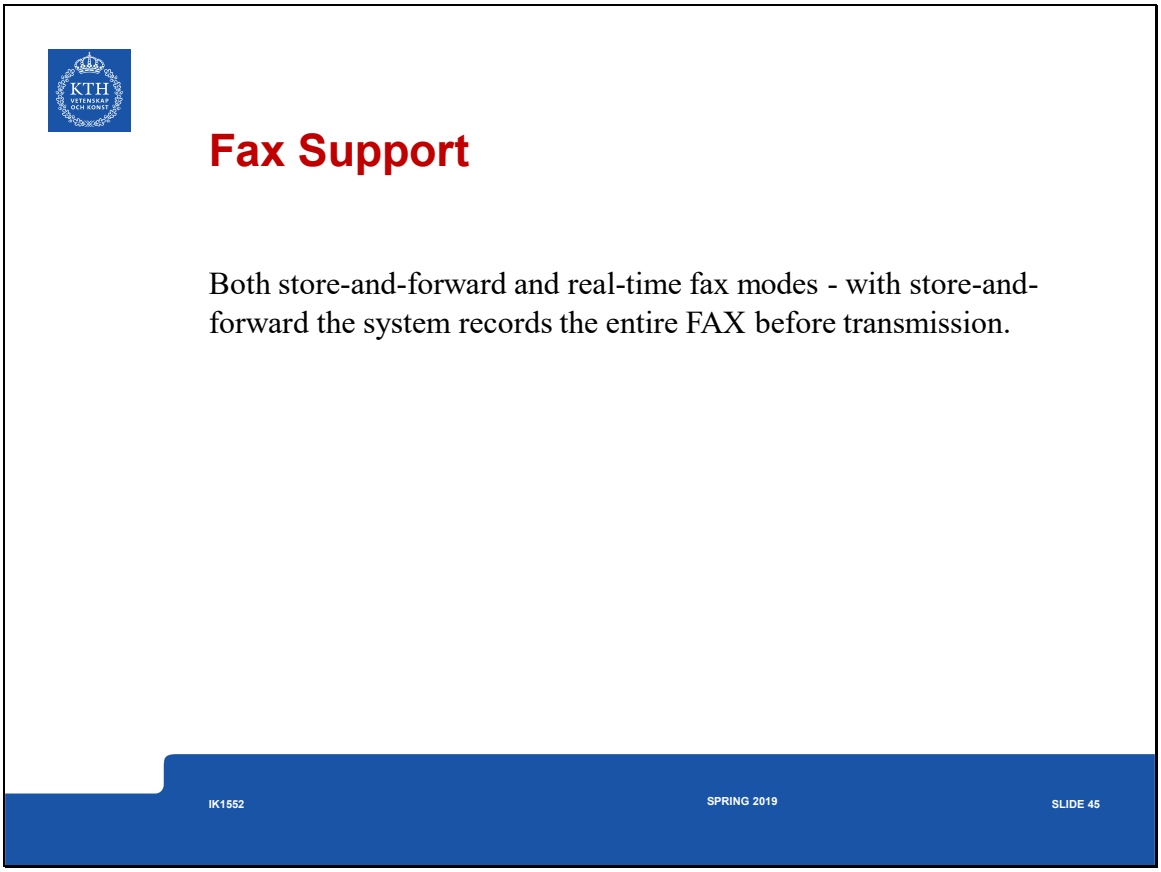
Fax Support
Both store-and-forward and real-time fax modes - with store-and-forward the system records the entire FAX before transmission.
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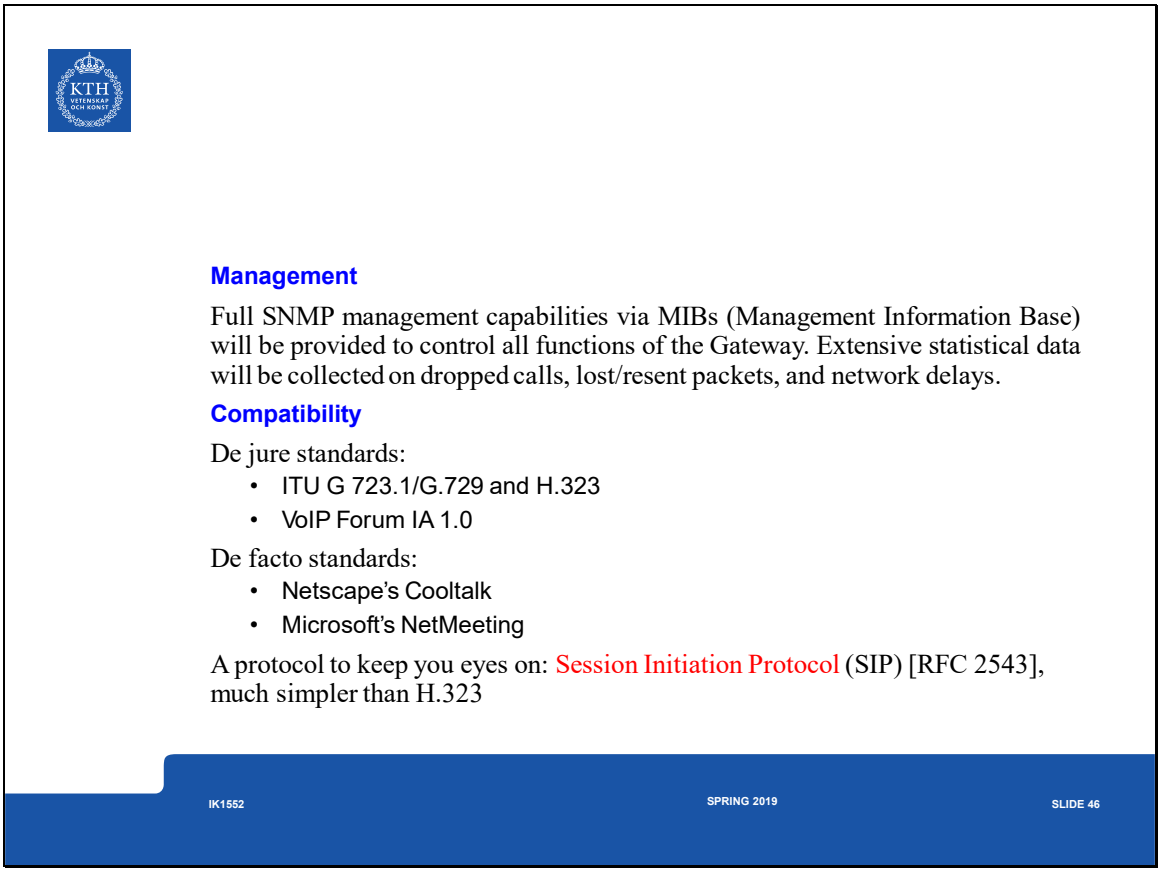

M. Handley, H. Schulzrinne, E. Schooler, and J. Rosenberg, 'SIP: Session Initiation Protocol', *Internet Request for Comments*, vol. RFC 2543 (Proposed Standard), March 1999, Available at http://www.rfc-editor.org/rfc/rfc2543.txt

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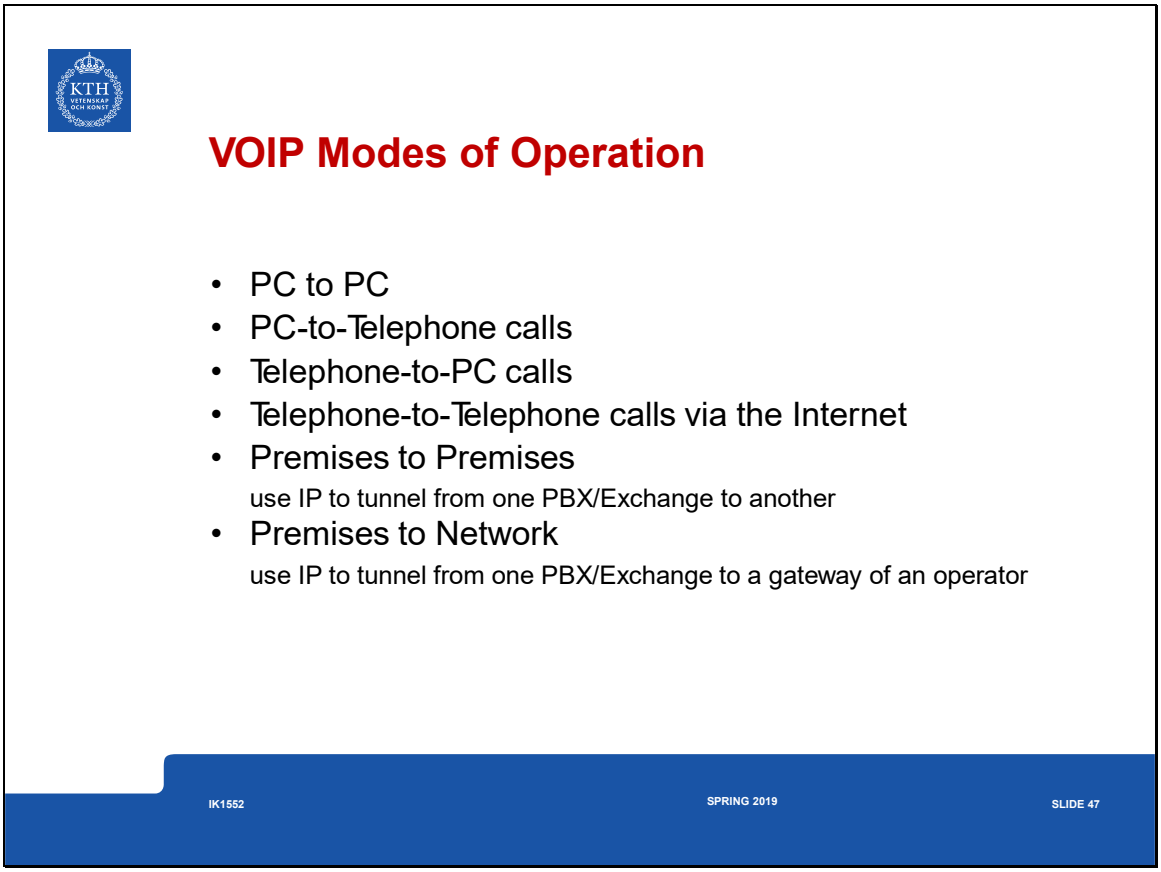
VOIP Modes of Operation
• PC to PC
• PC-to-Telephone calls
• Telephone-to-PC calls
• Telephone-to-Telephone calls via the Internet
• Premises to Premises
use IP to tunnel from one PBX/Exchange to another
• Premises to Network
use IP to tunnel from one PBX/Exchange to a gateway of an operator
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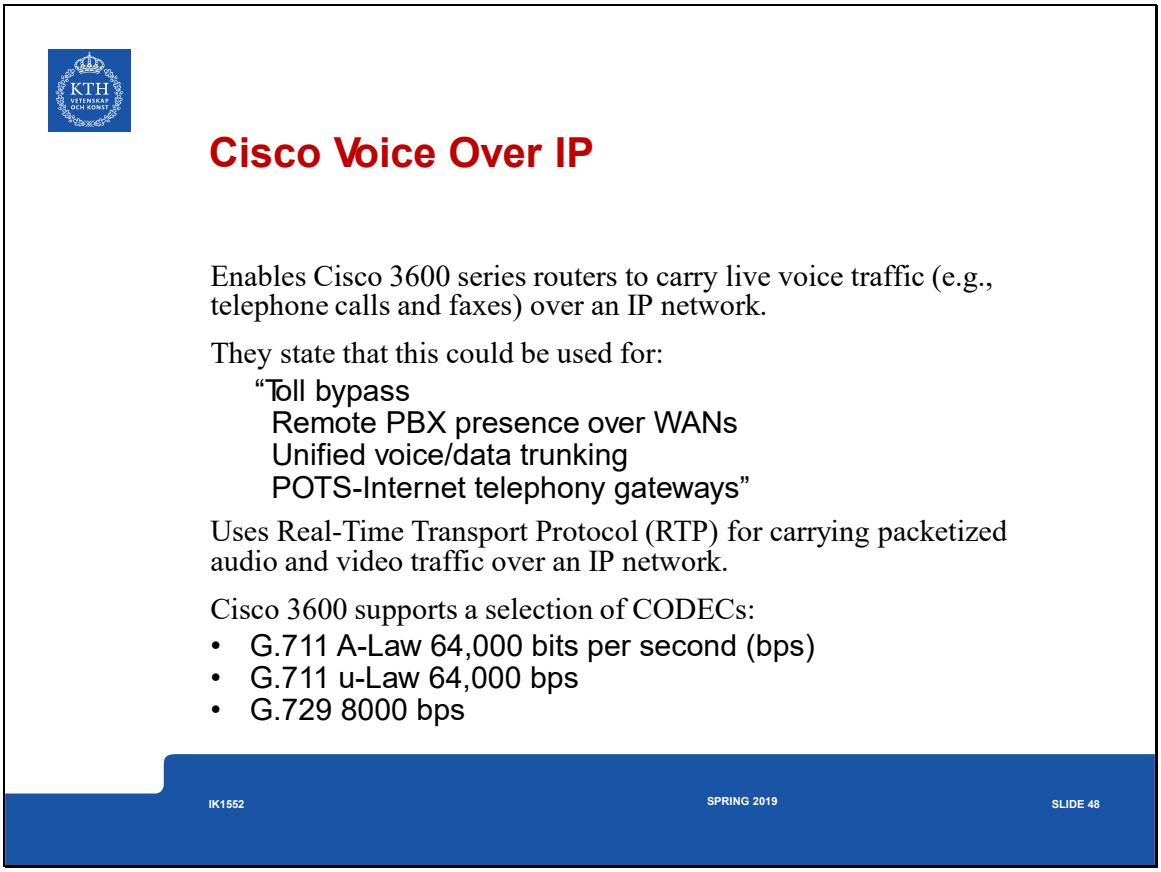

Information from
http://www.cisco.com/univercd/cc/td/doc/product/software/ios113ed/113t/113t_1/voip/config.htm

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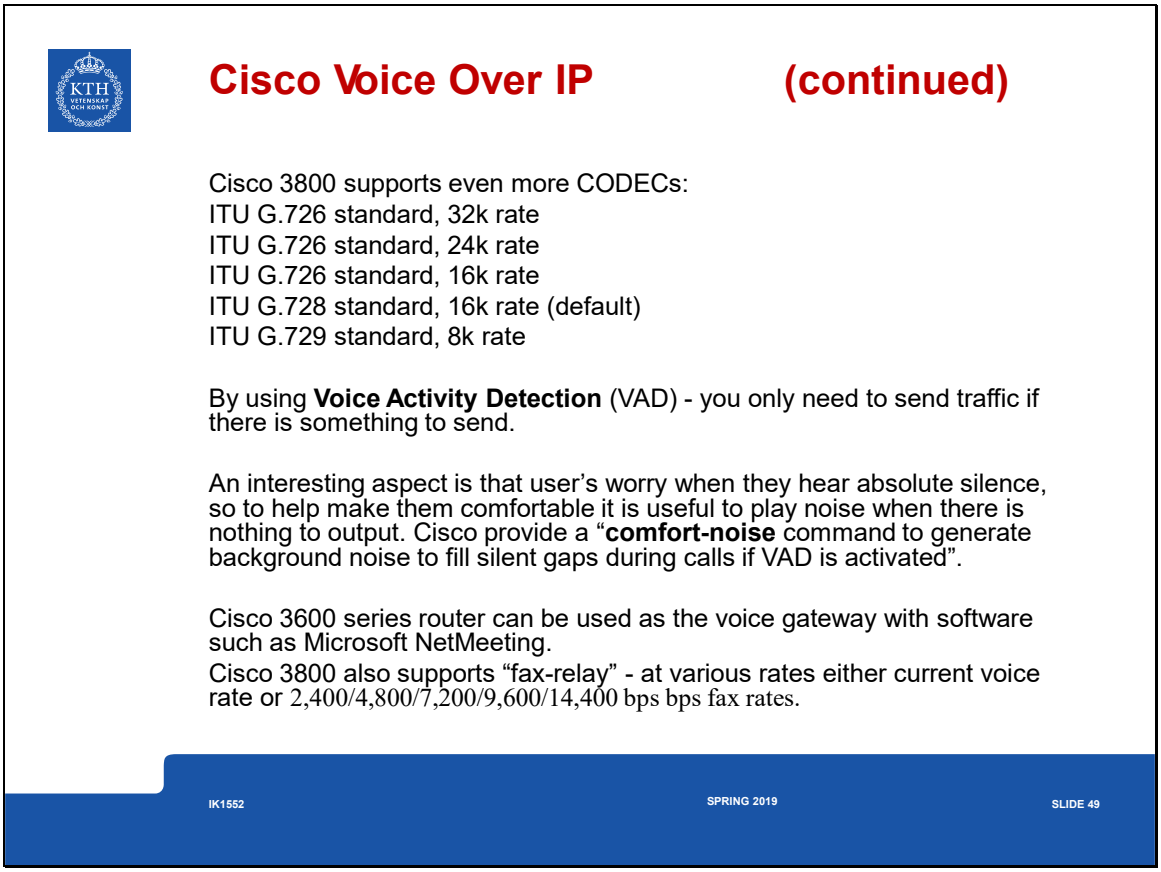
Cisco Voice Over IP (continued)
Cisco 3800 supports even more CODECs:
ITU G.726 standard, 32k rate
ITU G.726 standard, 24k rate
ITU G.726 standard, 16k rate
ITU G.728 standard, 16k rate (default)
ITU G.729 standard, 8k rate
By using Voice Activity Detection (VAD) - you only need to send traffic if there is something to send.
An interesting aspect is that user's worry when they hear absolute silence, so to help make them comfortable it is useful to play noise when there is nothing to output. Cisco provide a "comfort-noise command to generate background noise to fill silent gaps during calls if VAD is activated".
Cisco 3600 series router can be used as the voice gateway with software such as Microsoft NetMeeting.
Cisco 3800 also supports "fax-relay" - at various rates either current voice rate or 2,400/4,800/7,200/9,600/14,400 bps bps fax rates.
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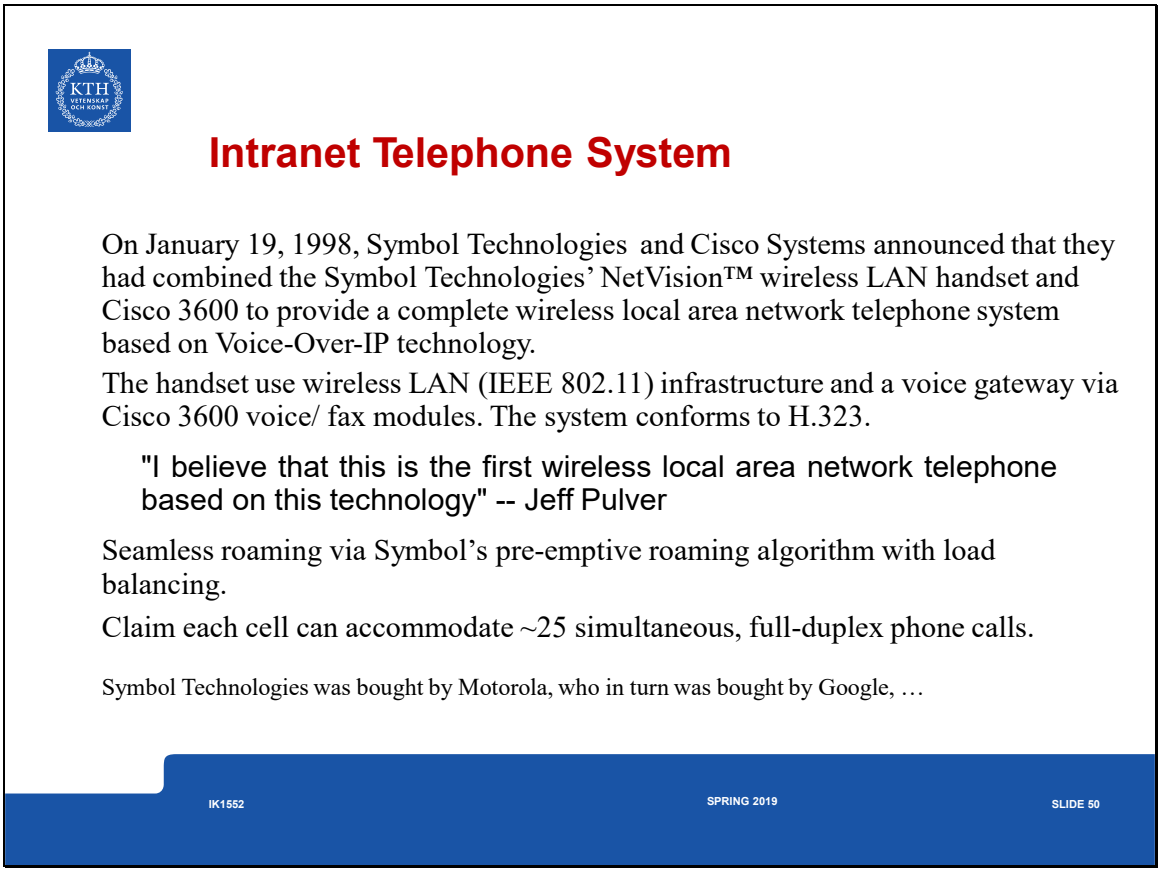

Intranet Telephone System

On January 19, 1998, Symbol Technologies and Cisco Systems announced that they had combined the Symbol Technologies' NetVision™ wireless LAN handset and Cisco 3600 to provide a complete wireless local area network telephone system based on Voice-Over-IP technology.

The handset use wireless LAN (IEEE 802.11) infrastructure and a voice gateway via Cisco 3600 voice/ fax modules. The system conforms to H.323.

> "I believe that this is the first wireless local area network telephone based on this technology" -- Jeff Pulver

Seamless roaming via Symbol's pre-emptive roaming algorithm with load balancing.

Claim each cell can accommodate ~25 simultaneous, full-duplex phone calls.

Symbol Technologies was bought by Motorola, who in turn was bought by Google, …

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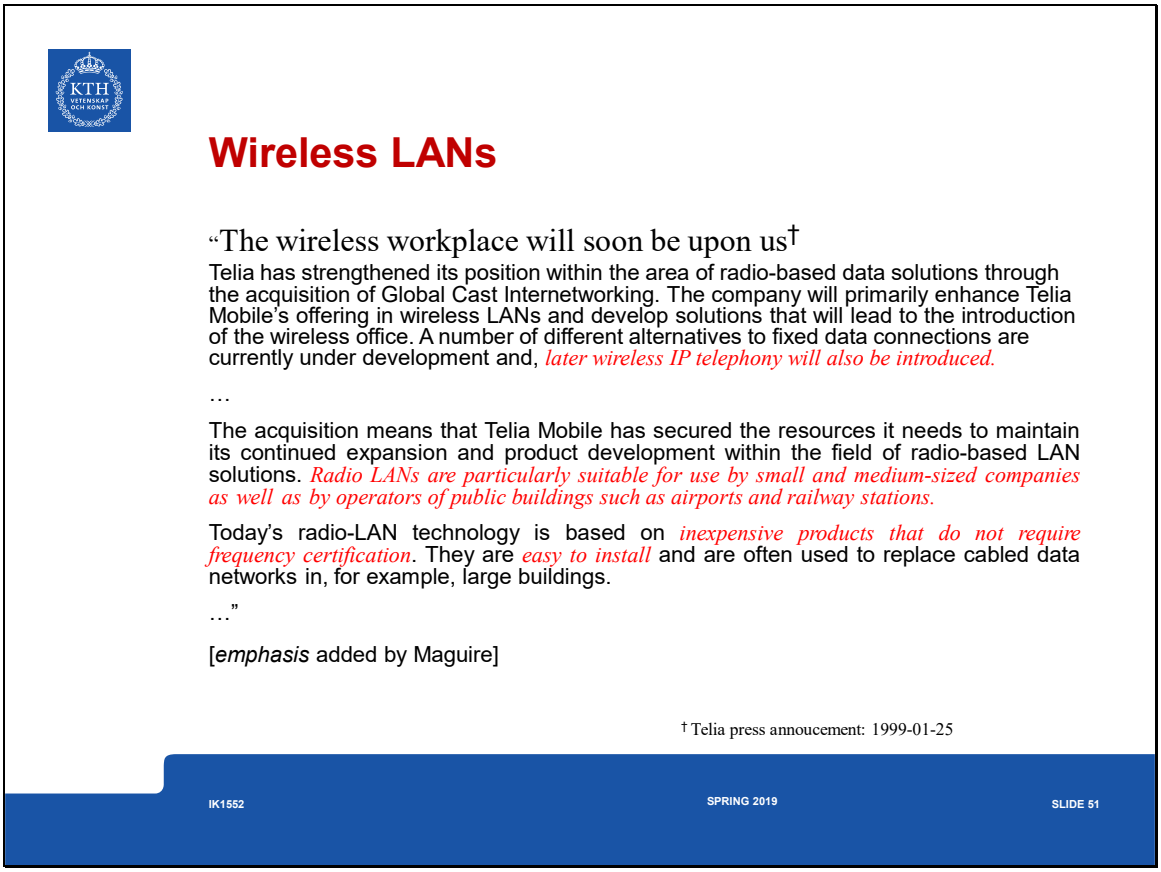
Wireless LANs
"The wireless workplace will soon be upon us†
Telia has strengthened its position within the area of radio-based data solutions through the acquisition of Global Cast Internetworking. The company will primarily enhance Telia Mobile's offering in wireless LANs and develop solutions that will lead to the introduction of the wireless office. A number of different alternatives to fixed data connections are currently under development and, later wireless IP telephony will also be introduced.
…
The acquisition means that Telia Mobile has secured the resources it needs to maintain its continued expansion and product development within the field of radio-based LAN solutions. Radio LANs are particularly suitable for use by small and medium-sized companies as well as by operators of public buildings such as airports and railway stations.
Today's radio-LAN technology is based on inexpensive products that do not require frequency certification. They are easy to install and are often used to replace cabled data networks in, for example, large buildings.
…"
[emphasis added by Maguire]
† Telia press annoucement: 1999-01-25
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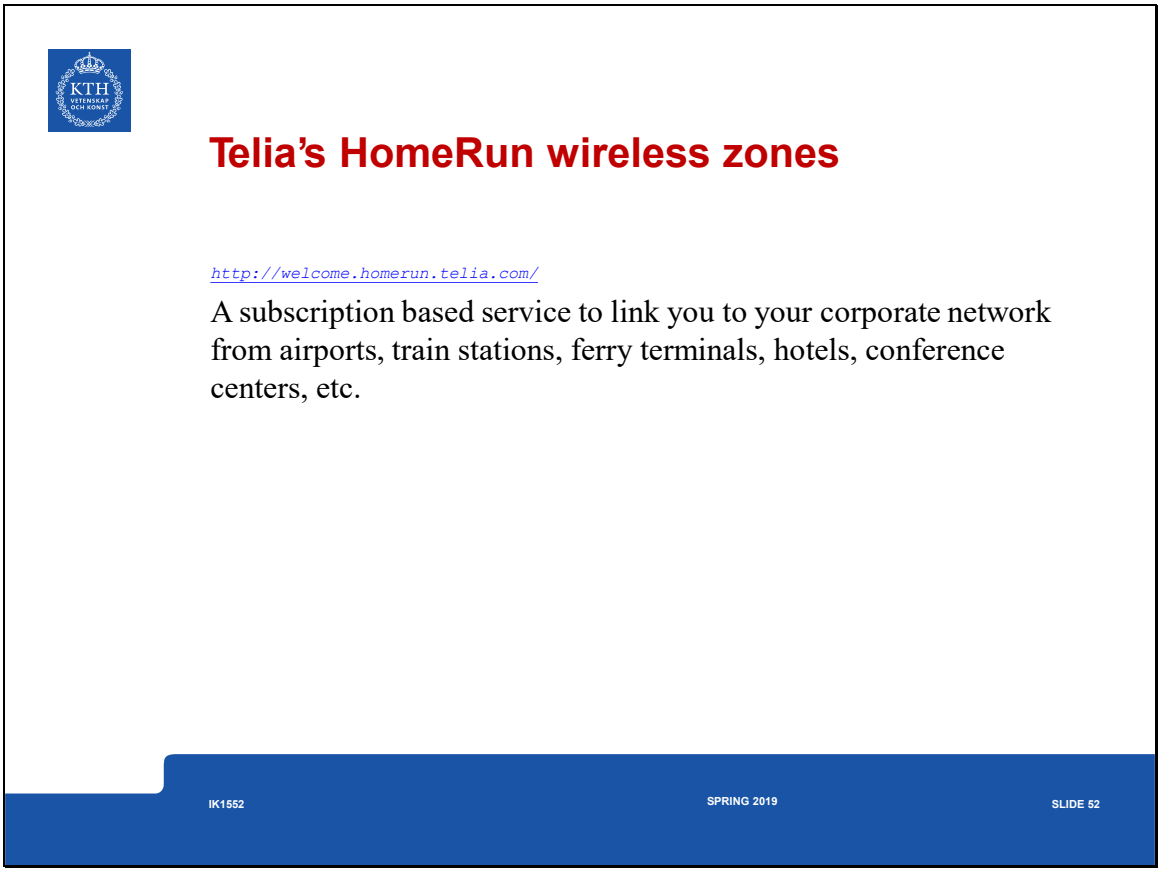
Telia's HomeRun wireless zones
http://welcome.homerun.telia.com/
A subscription based service to link you to your corporate network from airports, train stations, ferry terminals, hotels, conference centers, etc.
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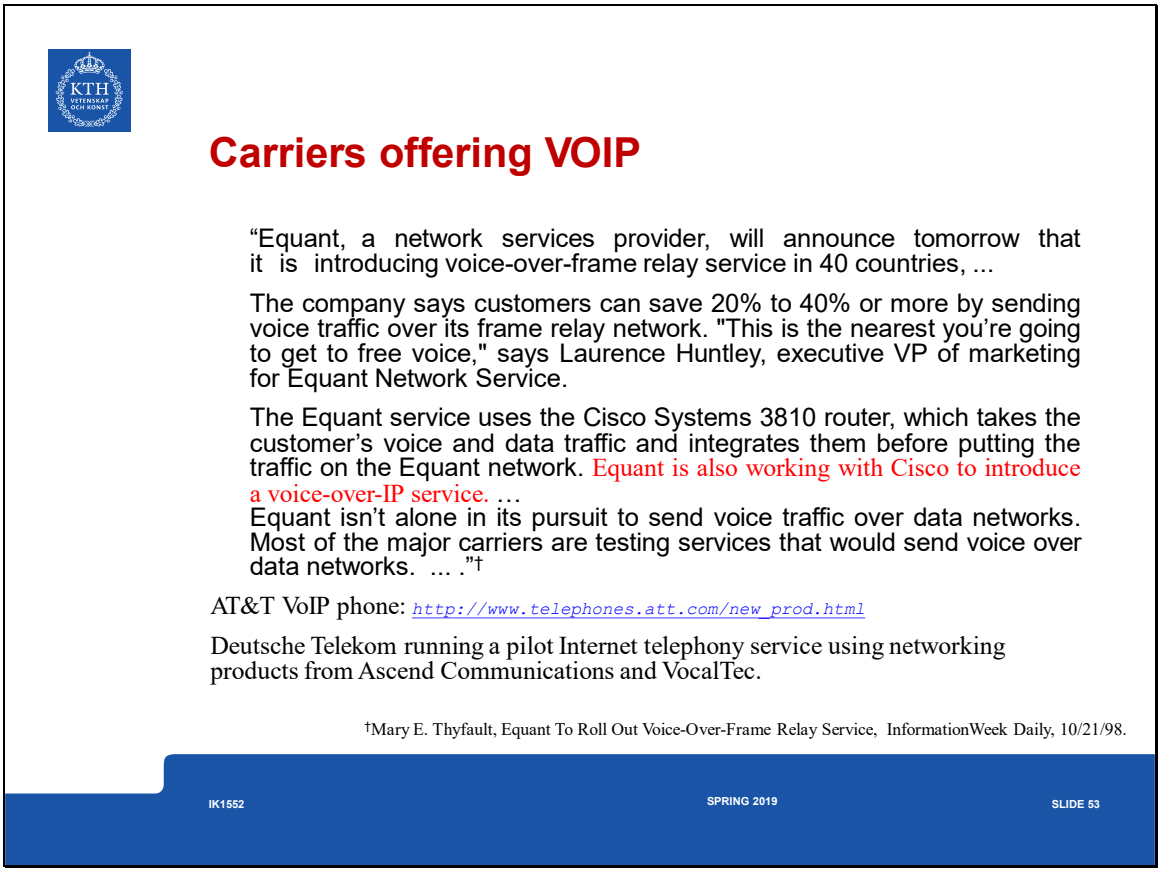
Carriers offering VOIP
"Equant, a network services provider, will announce tomorrow that it is introducing voice-over-frame relay service in 40 countries, ...
The company says customers can save 20% to 40% or more by sending voice traffic over its frame relay network. "This is the nearest you're going to get to free voice," says Laurence Huntley, executive VP of marketing for Equant Network Service.
The Equant service uses the Cisco Systems 3810 router, which takes the customer's voice and data traffic and integrates them before putting the traffic on the Equant network. Equant is also working with Cisco to introduce a voice-over-IP service. …
Equant isn't alone in its pursuit to send voice traffic over data networks. Most of the major carriers are testing services that would send voice over data networks. ... ."†
AT&T VoIP phone: http://www.telephones.att.com/new_prod.html
Deutsche Telekom running a pilot Internet telephony service using networking products from Ascend Communications and VocalTec.
†Mary E. Thyfault, Equant To Roll Out Voice-Over-Frame Relay Service, InformationWeek Daily, 10/21/98.
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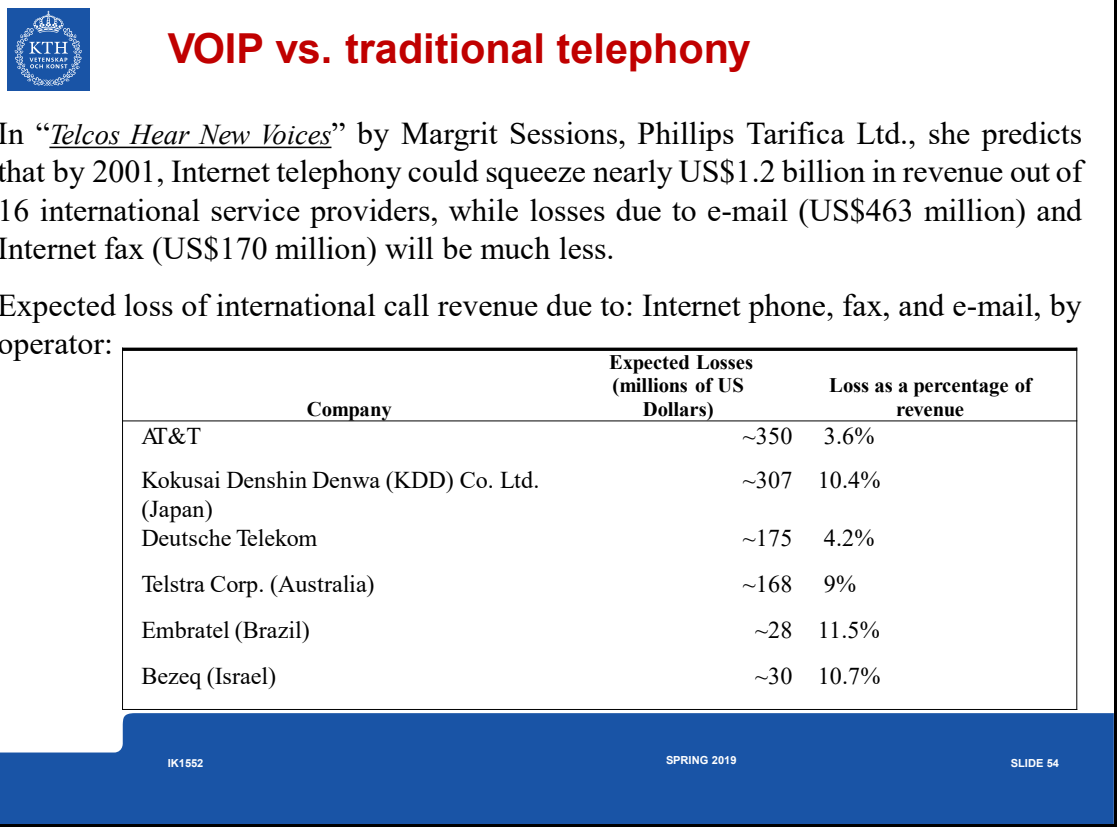

VOIP vs. traditional telephony

In "*Telcos Hear New Voices*" by Margrit Sessions, Phillips Tarifica Ltd., she predicts that by 2001, Internet telephony could squeeze nearly US$1.2 billion in revenue out of 16 international service providers, while losses due to e-mail (US$463 million) and Internet fax (US$170 million) will be much less.

Expected loss of international call revenue due to: Internet phone, fax, and e-mail, by operator:

Company	Expected Losses (millions of US Dollars)	Loss as a percentage of revenue
AT&T	~350	3.6%
Kokusai Denshin Denwa (KDD) Co. Ltd. (Japan)	~307	10.4%
Deutsche Telekom	~175	4.2%
Telstra Corp. (Australia)	~168	9%
Embratel (Brazil)	~28	11.5%
Bezeq (Israel)	~30	10.7%

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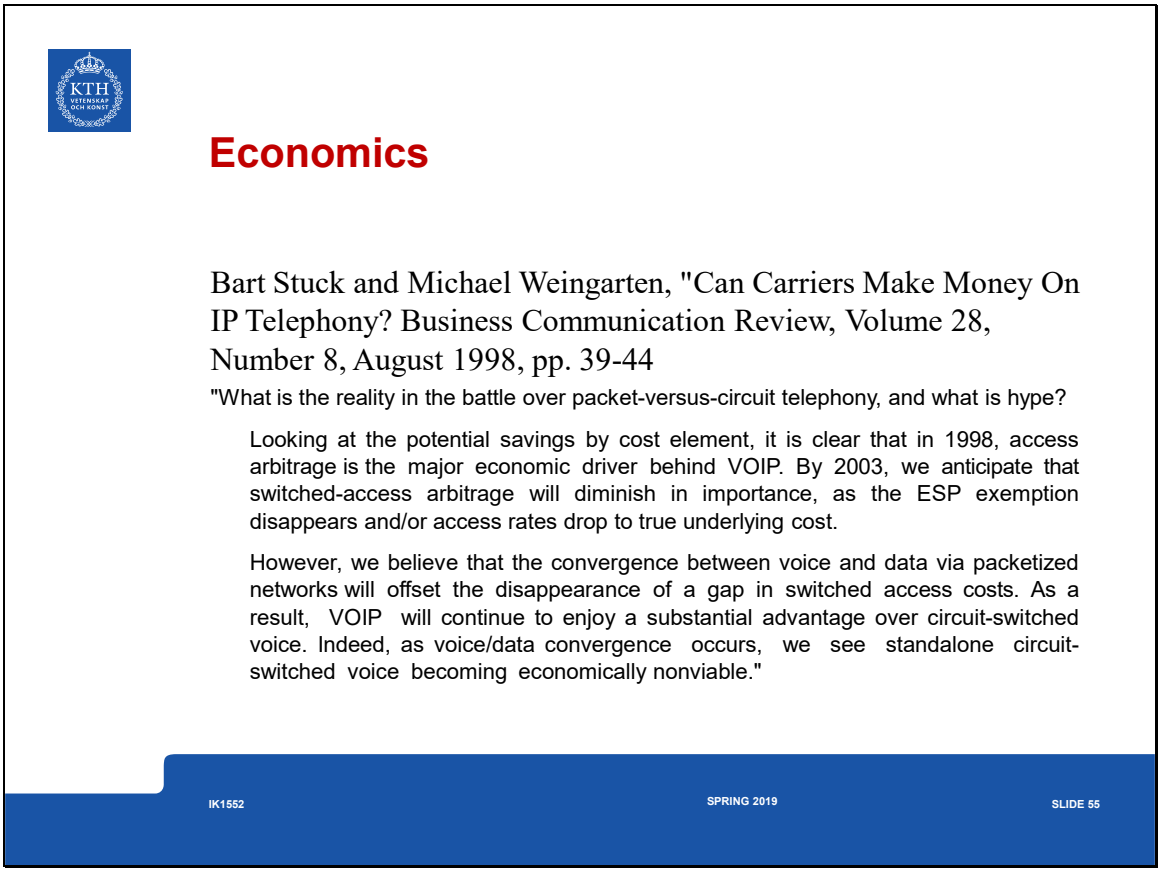
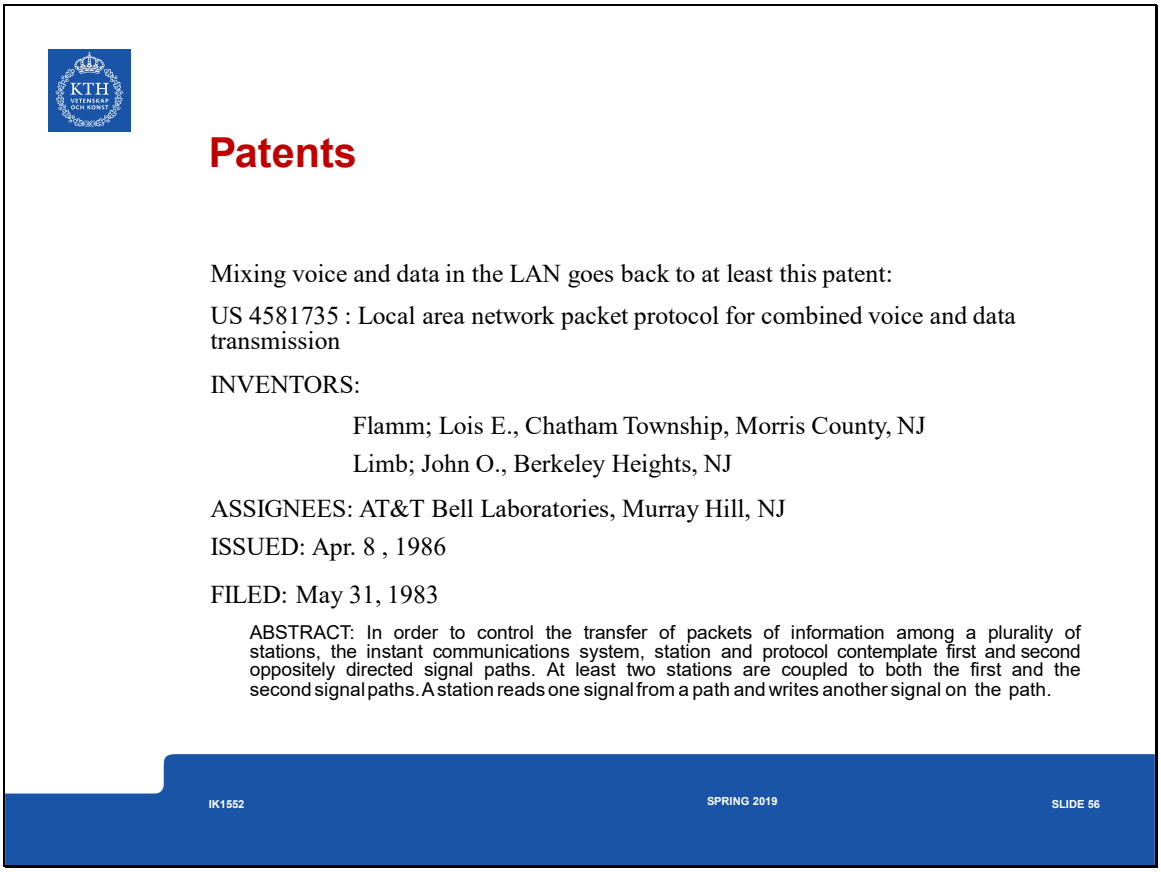


Bart Stuck and Michael Weingarten, "Can Carriers Make Money On IP Telephony? Business Communication Review, Volume 28, Number 8, August 1998, pp. 39-44
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1877464


Patents
Mixing voice and data in the LAN goes back to at least this patent:
US 4581735 : Local area network packet protocol for combined voice and data transmission
INVENTORS:
Flamm; Lois E., Chatham Township, Morris County, NJ
Limb; John O., Berkeley Heights, NJ
ASSIGNEES: AT&T Bell Laboratories, Murray Hill, NJ
ISSUED: Apr. 8 , 1986
FILED: May 31, 1983
ABSTRACT: In order to control the transfer of packets of information among a plurality of stations, the instant communications system, station and protocol contemplate first and second oppositely directed signal paths. At least two stations are coupled to both the first and the second signal paths. A station reads one signal from a path and writes another signal on the path.
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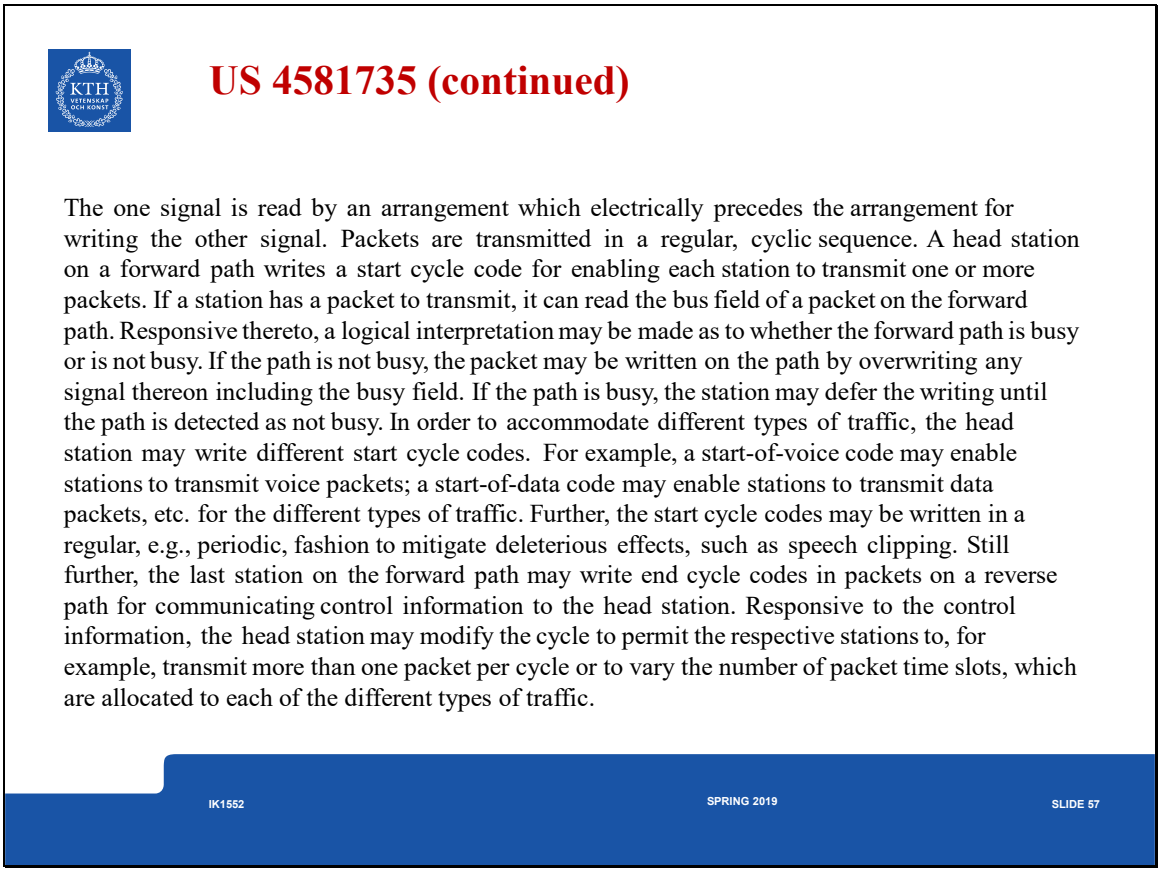

US 4581735 (continued)

The one signal is read by an arrangement which electrically precedes the arrangement for writing the other signal. Packets are transmitted in a regular, cyclic sequence. A head station on a forward path writes a start cycle code for enabling each station to transmit one or more packets. If a station has a packet to transmit, it can read the bus field of a packet on the forward path. Responsive thereto, a logical interpretation may be made as to whether the forward path is busy or is not busy. If the path is not busy, the packet may be written on the path by overwriting any signal thereon including the busy field. If the path is busy, the station may defer the writing until the path is detected as not busy. In order to accommodate different types of traffic, the head station may write different start cycle codes. For example, a start-of-voice code may enable stations to transmit voice packets; a start-of-data code may enable stations to transmit data packets, etc. for the different types of traffic. Further, the start cycle codes may be written in a regular, e.g., periodic, fashion to mitigate deleterious effects, such as speech clipping. Still further, the last station on the forward path may write end cycle codes in packets on a reverse path for communicating control information to the head station. Responsive to the control information, the head station may modify the cycle to permit the respective stations to, for example, transmit more than one packet per cycle or to vary the number of packet time slots, which are allocated to each of the different types of traffic.

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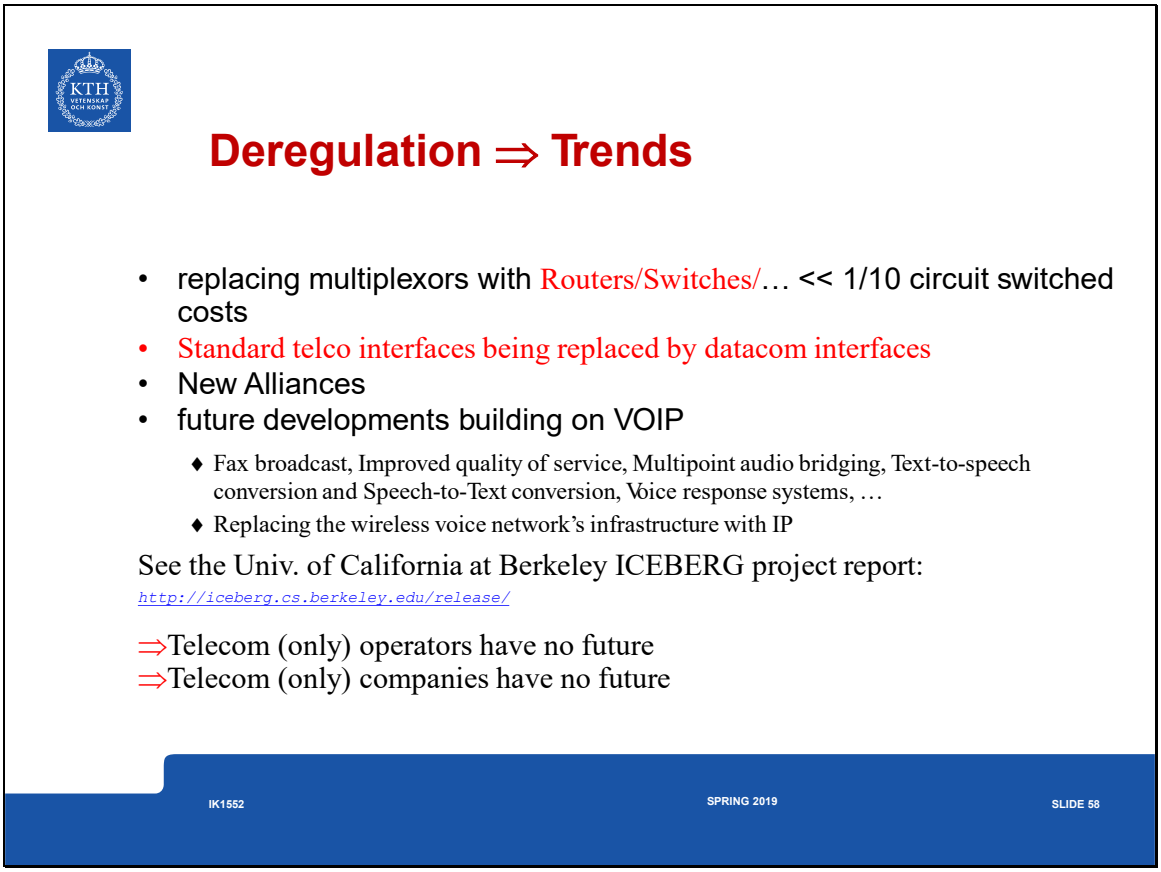
Deregulation ⇒ Trends
• replacing multiplexors with Routers/Switches/… << 1/10 circuit switched costs
• Standard telco interfaces being replaced by datacom interfaces
• New Alliances
• future developments building on VOIP
♦ Fax broadcast, Improved quality of service, Multipoint audio bridging, Text-to-speech conversion and Speech-to-Text conversion, Voice response systems, …
♦ Replacing the wireless voice network's infrastructure with IP
See the Univ. of California at Berkeley ICEBERG project report:
http://iceberg.cs.berkeley.edu/release/
⇒Telecom (only) operators have no future
⇒Telecom (only) companies have no future
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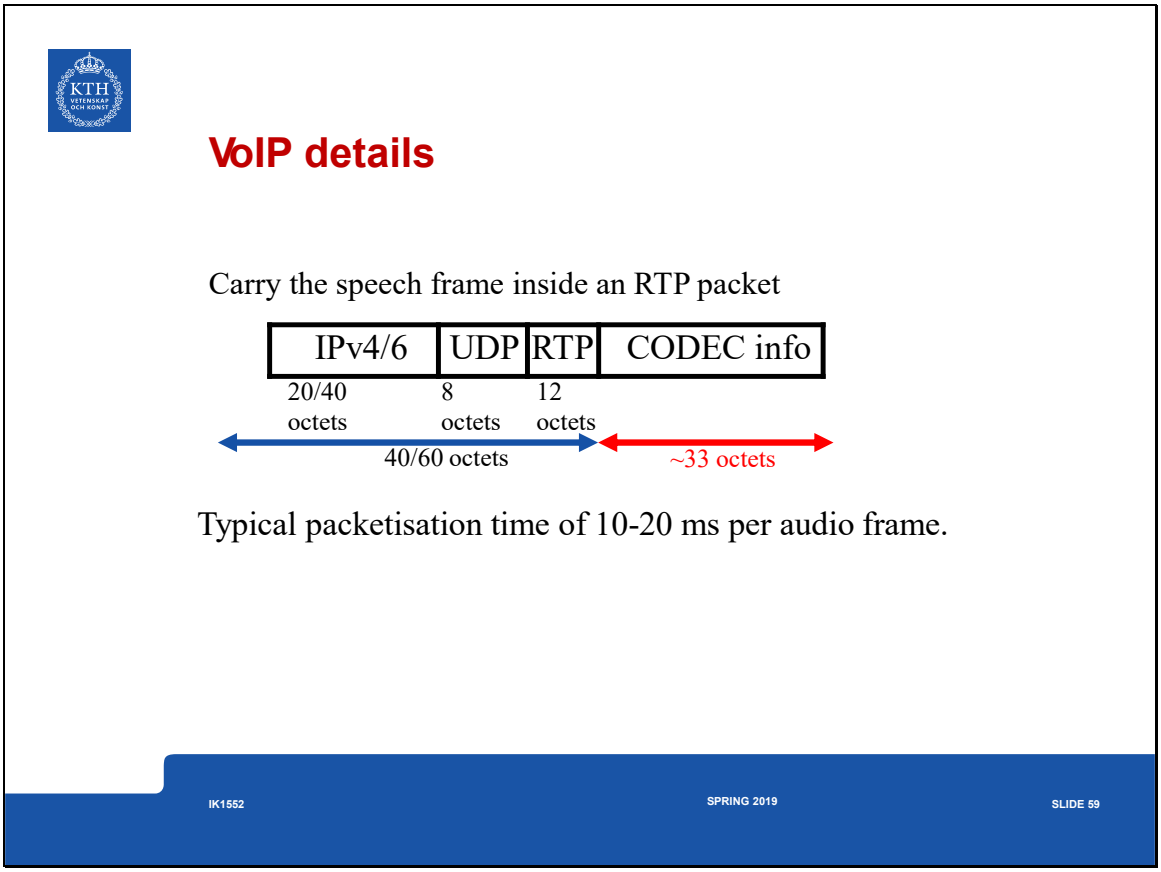
VoIP details
Carry the speech frame inside an RTP packet
IPv4/6
UDP
RTP
CODEC info
20/40 octets
8 octets
12 octets
40/60 octets
~33 octets
Typical packetisation time of 10-20 ms per audio frame.
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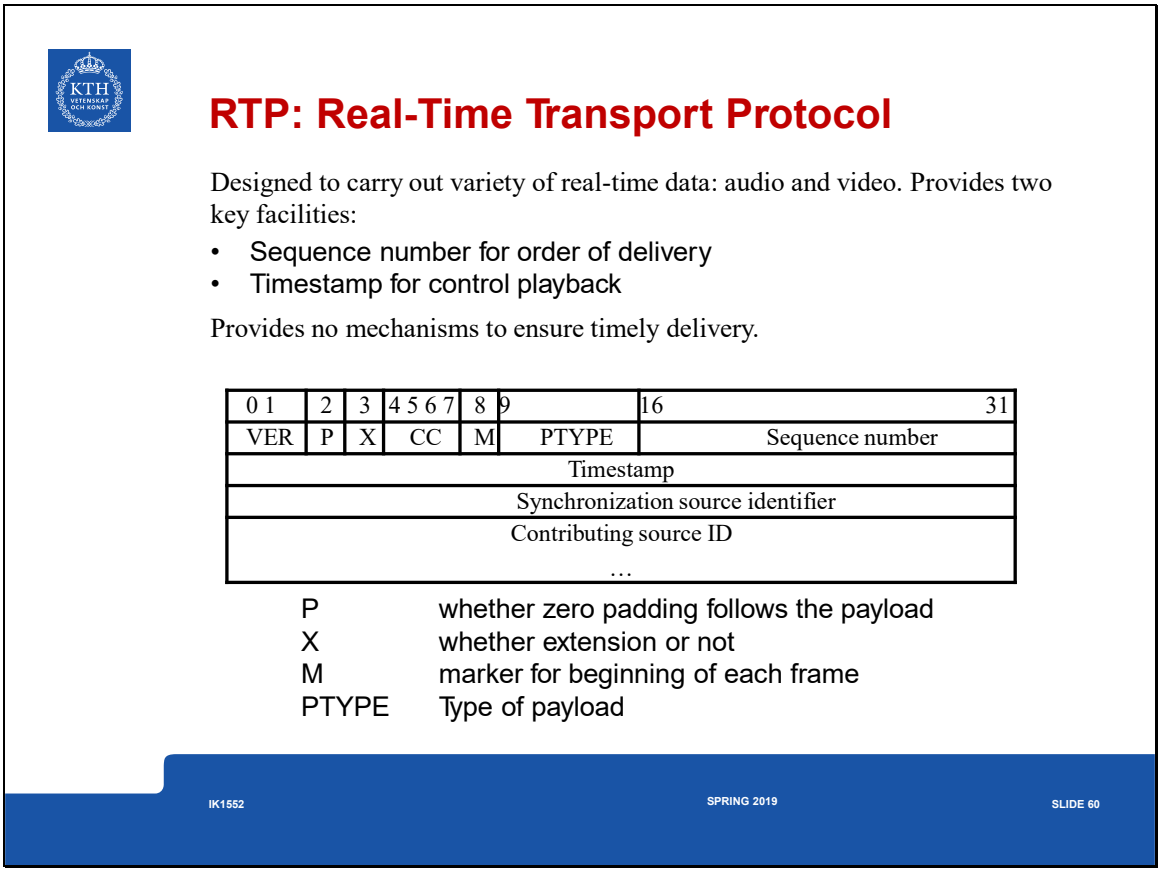
RTP: Real-Time Transport Protocol
Designed to carry out variety of real-time data: audio and video. Provides two key facilities:
• Sequence number for order of delivery
• Timestamp for control playback
Provides no mechanisms to ensure timely delivery.
0 1 2 3 4 5 6 7 8 9 16 31
VER P X CC M PTYPE Sequence number
Timestamp
Synchronization source identifier
Contributing source ID
…
P whether zero padding follows the payload
X whether extension or not
M marker for beginning of each frame
PTYPE Type of payload
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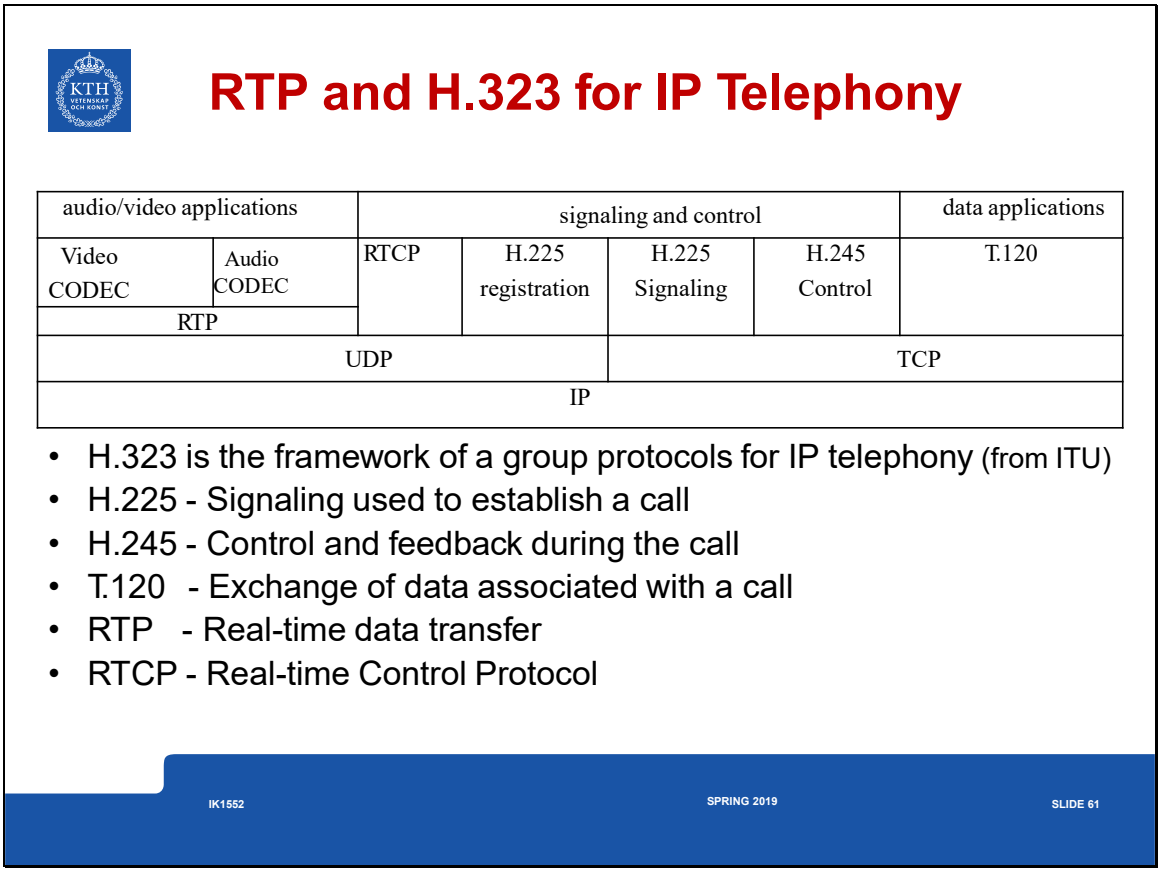
RTP and H.323 for IP Telephony
audio/video applications
signaling and control
data applications
Video CODEC
Audio CODEC
RTCP
H.225 registration
H.225 Signaling
H.245 Control
T.120
RTP
UDP
TCP
IP
• H.323 is the framework of a group protocols for IP telephony (from ITU)
• H.225 - Signaling used to establish a call
• H.245 - Control and feedback during the call
• T.120 - Exchange of data associated with a call
• RTP - Real-time data transfer
• RTCP - Real-time Control Protocol
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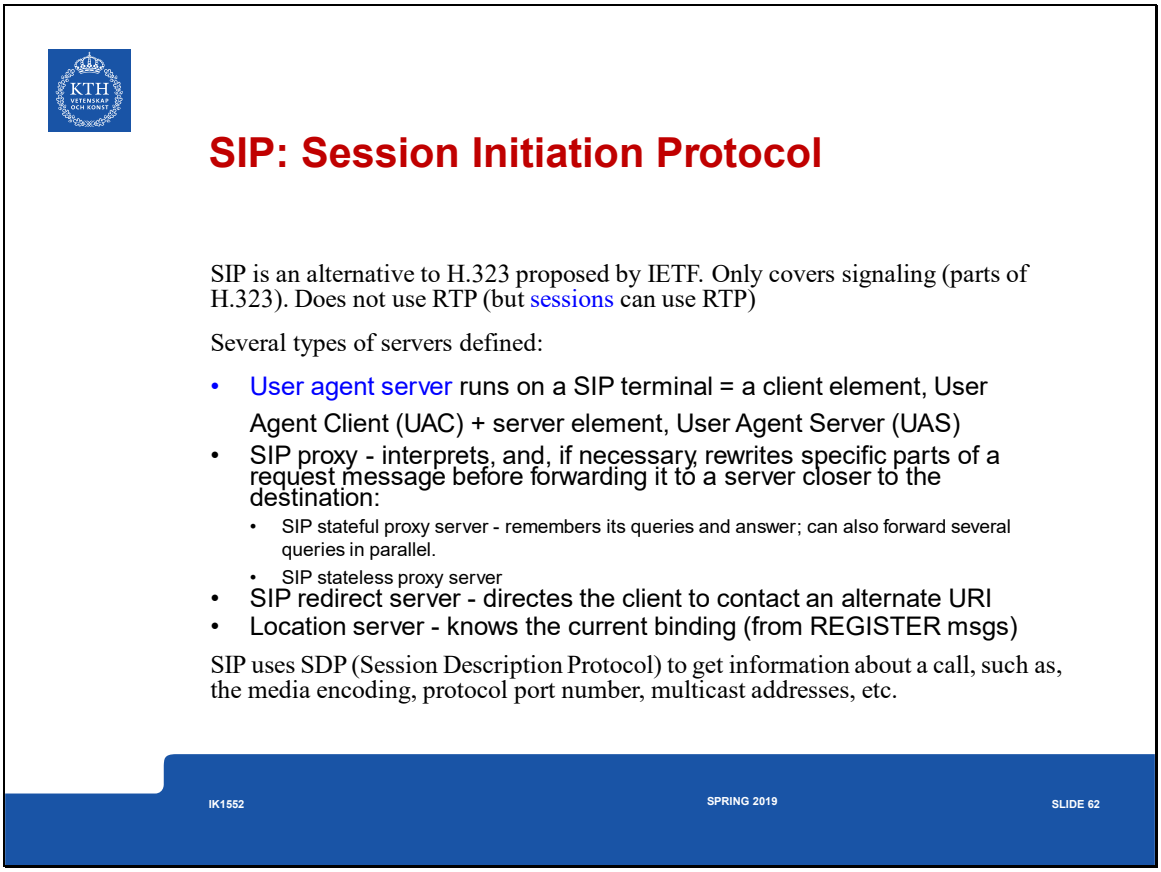
SIP: Session Initiation Protocol
SIP is an alternative to H.323 proposed by IETF. Only covers signaling (parts of H.323). Does not use RTP (but sessions can use RTP)
Several types of servers defined:
User agent server runs on a SIP terminal = a client element, User Agent Client (UAC) + server element, User Agent Server (UAS)
SIP proxy - interprets, and, if necessary, rewrites specific parts of a request message before forwarding it to a server closer to the destination:
SIP stateful proxy server - remembers its queries and answer; can also forward several queries in parallel.
SIP stateless proxy server
SIP redirect server - directes the client to contact an alternate URI
Location server - knows the current binding (from REGISTER msgs)
SIP uses SDP (Session Description Protocol) to get information about a call, such as, the media encoding, protocol port number, multicast addresses, etc.
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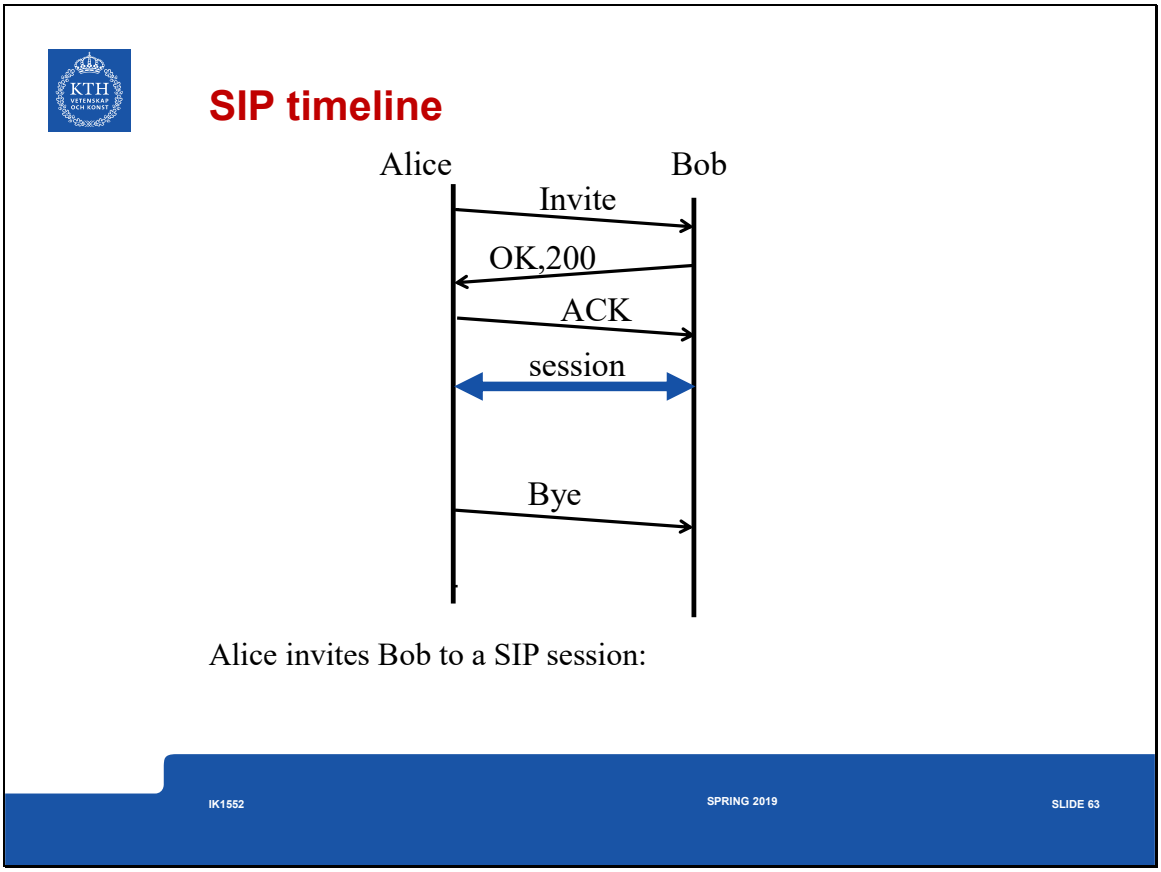
SIP timeline
Alice
Bob
Invite
OK,200
ACK
session
Bye
Alice invites Bob to a SIP session:
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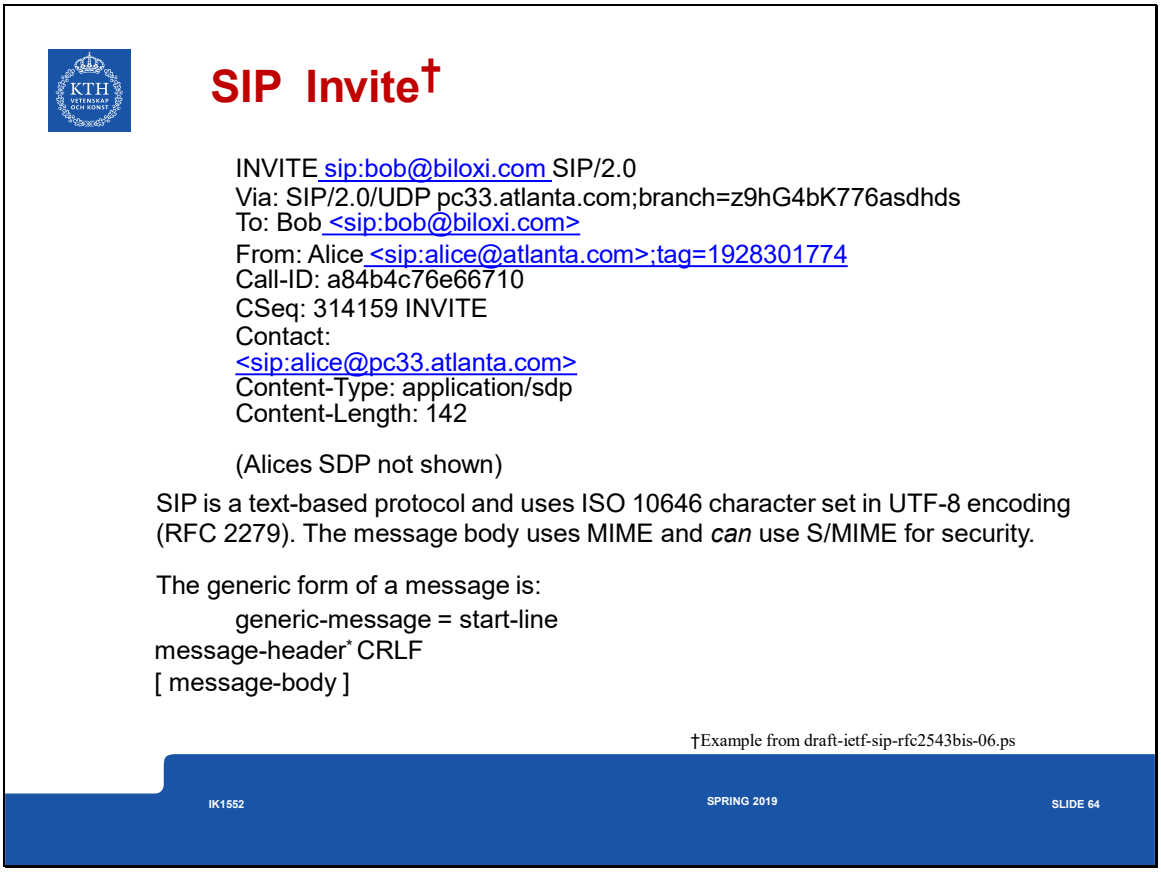
SIP Invite†
INVITE sip:bob@biloxi.com SIP/2.0
Via: SIP/2.0/UDP pc33.atlanta.com;branch=z9hG4bK776asdhds
To: Bob <sip:bob@biloxi.com>
From: Alice <sip:alice@atlanta.com>;tag=1928301774
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Contact:
<sip:alice@pc33.atlanta.com>
Content-Type: application/sdp
Content-Length: 142
(Alices SDP not shown)
SIP is a text-based protocol and uses ISO 10646 character set in UTF-8 encoding (RFC 2279). The message body uses MIME and can use S/MIME for security.
The generic form of a message is:
generic-message = start-line
message-header* CRLF
[message-body]
†Example from draft-ietf-sip-rfc2543bis-06.ps
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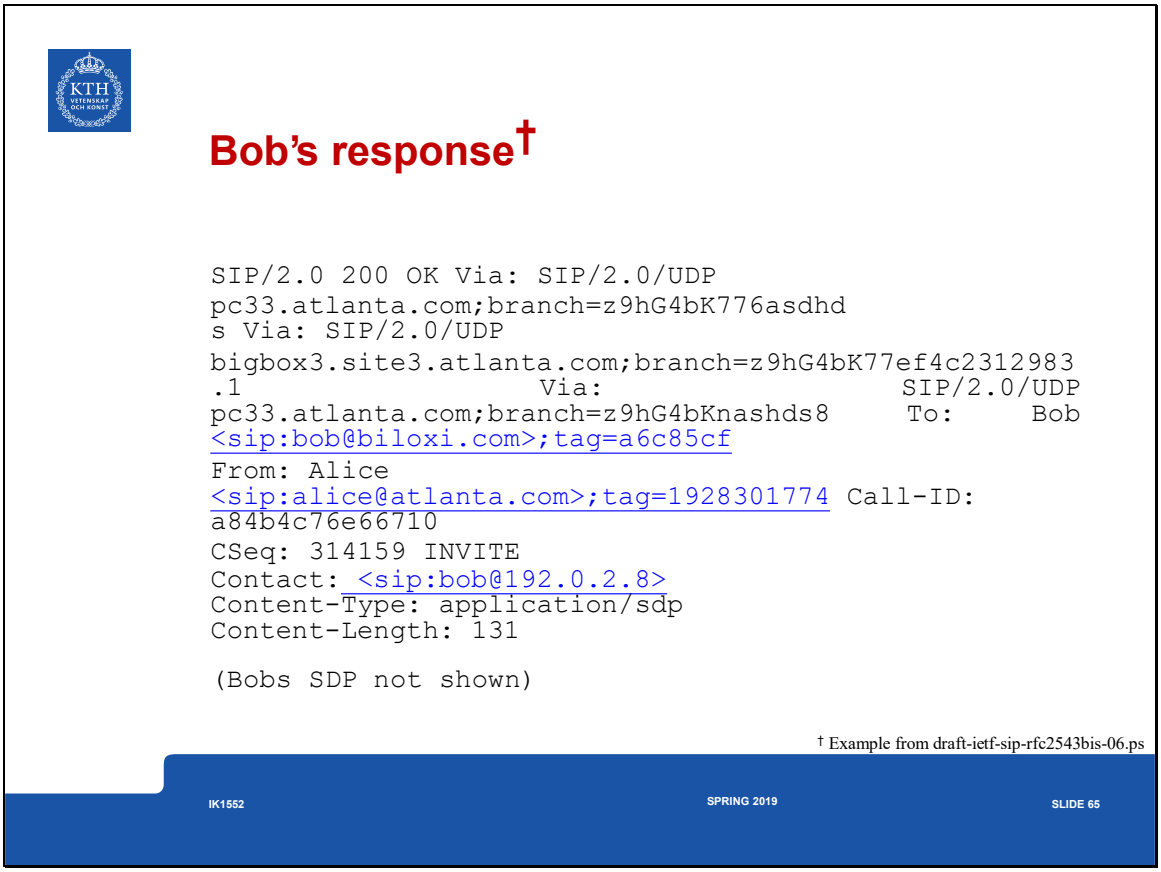
Bob's response†
SIP/2.0 200 OK Via: SIP/2.0/UDP
pc33.atlanta.com;branch=z9hG4bK776asdhd
s Via: SIP/2.0/UDP
bigbox3.site3.atlanta.com;branch=z9hG4bK77ef4c2312983
.1 Via: SIP/2.0/UDP
pc33.atlanta.com;branch=z9hG4bKnashds8 To: Bob
<sip:bob@biloxi.com>;tag=a6c85cf
From: Alice
<sip:alice@atlanta.com>;tag=1928301774 Call-ID:
a84b4c76e66710
CSeq: 314159 INVITE
Contact: <sip:bob@192.0.2.8>
Content-Type: application/sdp
Content-Length: 131
(Bobs SDP not shown)
† Example from draft-ietf-sip-rfc2543bis-06.ps
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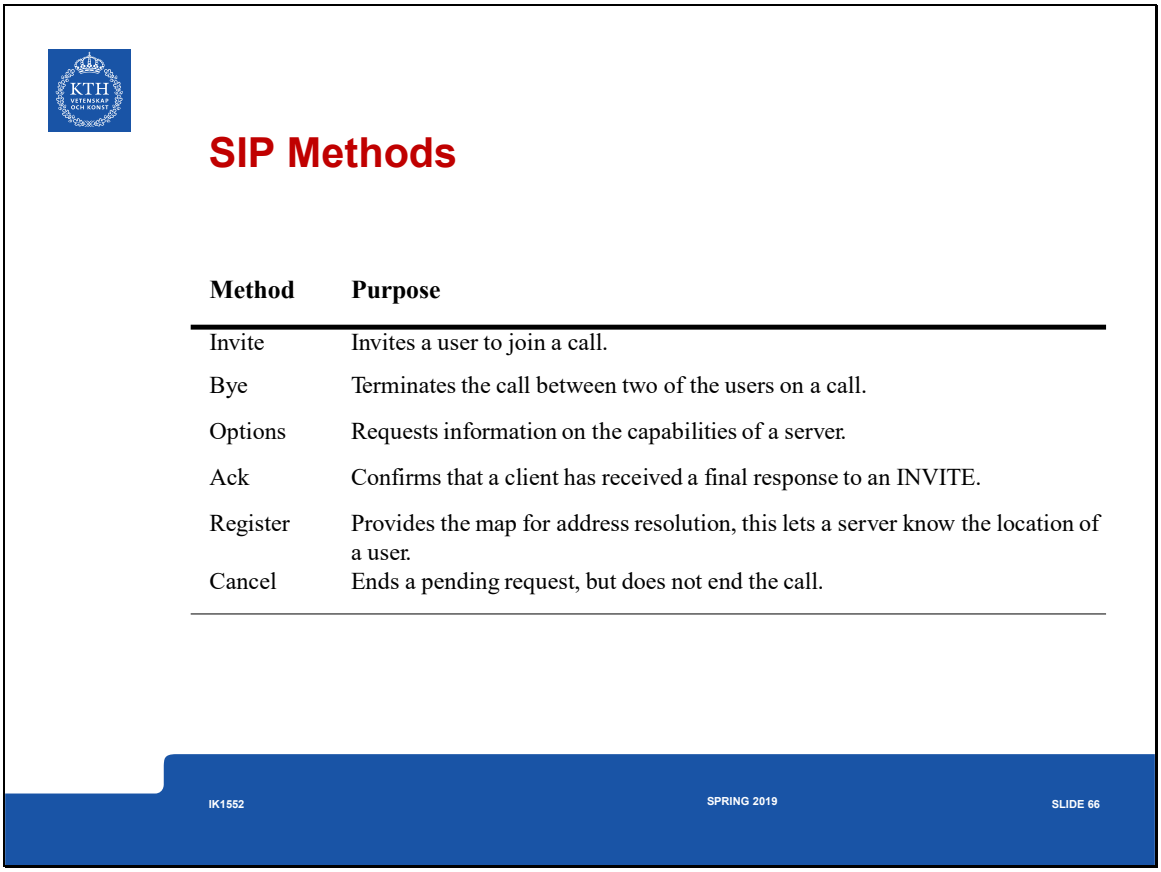

SIP Methods

Method	Purpose
Invite	Invites a user to join a call.
Bye	Terminates the call between two of the users on a call.
Options	Requests information on the capabilities of a server.
Ack	Confirms that a client has received a final response to an INVITE.
Register	Provides the map for address resolution, this lets a server know the location of a user.
Cancel	Ends a pending request, but does not end the call.

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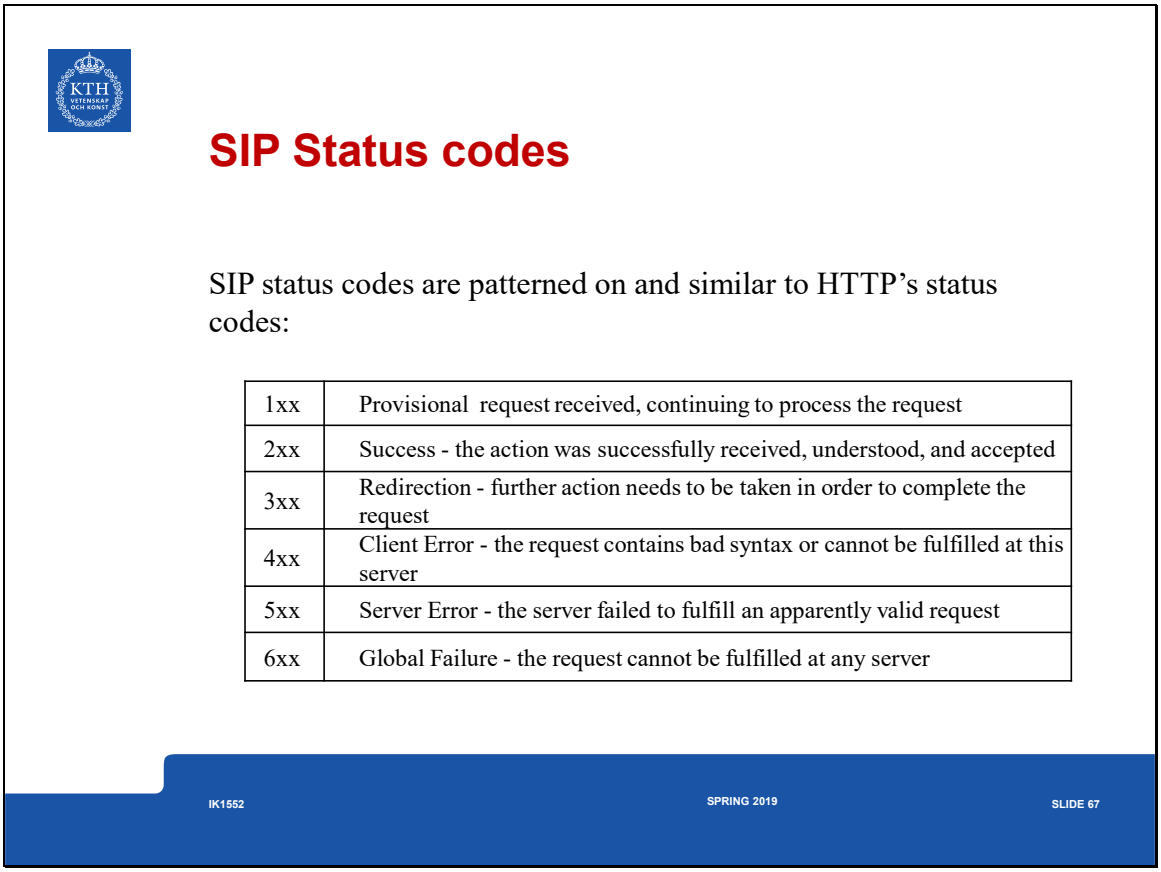

SIP Status codes

SIP status codes are patterned on and similar to HTTP's status codes:

1xx	Provisional request received, continuing to process the request
2xx	Success - the action was successfully received, understood, and accepted
3xx	Redirection - further action needs to be taken in order to complete the request
4xx	Client Error - the request contains bad syntax or cannot be fulfilled at this server
5xx	Server Error - the server failed to fulfill an apparently valid request
6xx	Global Failure - the request cannot be fulfilled at any server

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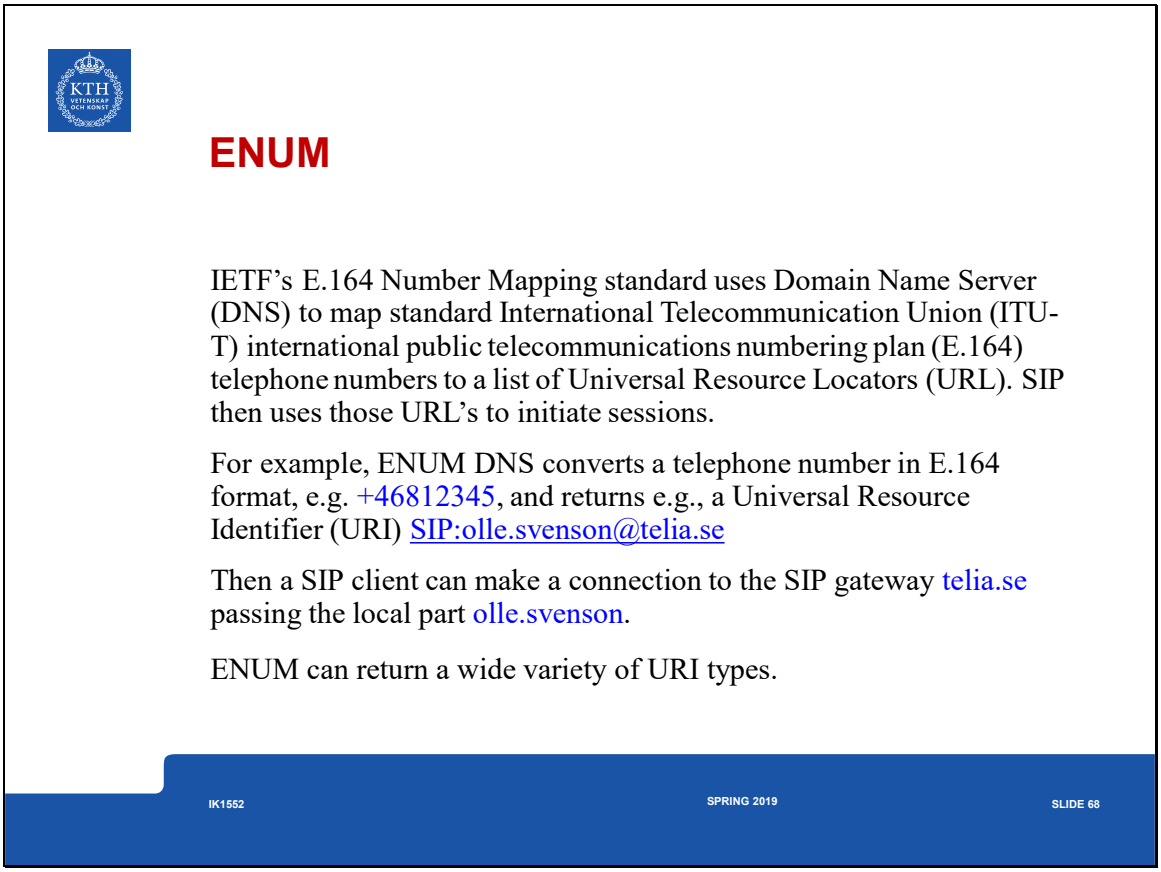
ENUM
IETF's E.164 Number Mapping standard uses Domain Name Server (DNS) to map standard International Telecommunication Union (ITU-T) international public telecommunications numbering plan (E.164) telephone numbers to a list of Universal Resource Locators (URL). SIP then uses those URL's to initiate sessions.
For example, ENUM DNS converts a telephone number in E.164 format, e.g. +46812345, and returns e.g., a Universal Resource Identifier (URI) SIP:olle.svenson@telia.se
Then a SIP client can make a connection to the SIP gateway telia.se passing the local part olle.svenson.
ENUM can return a wide variety of URI types.
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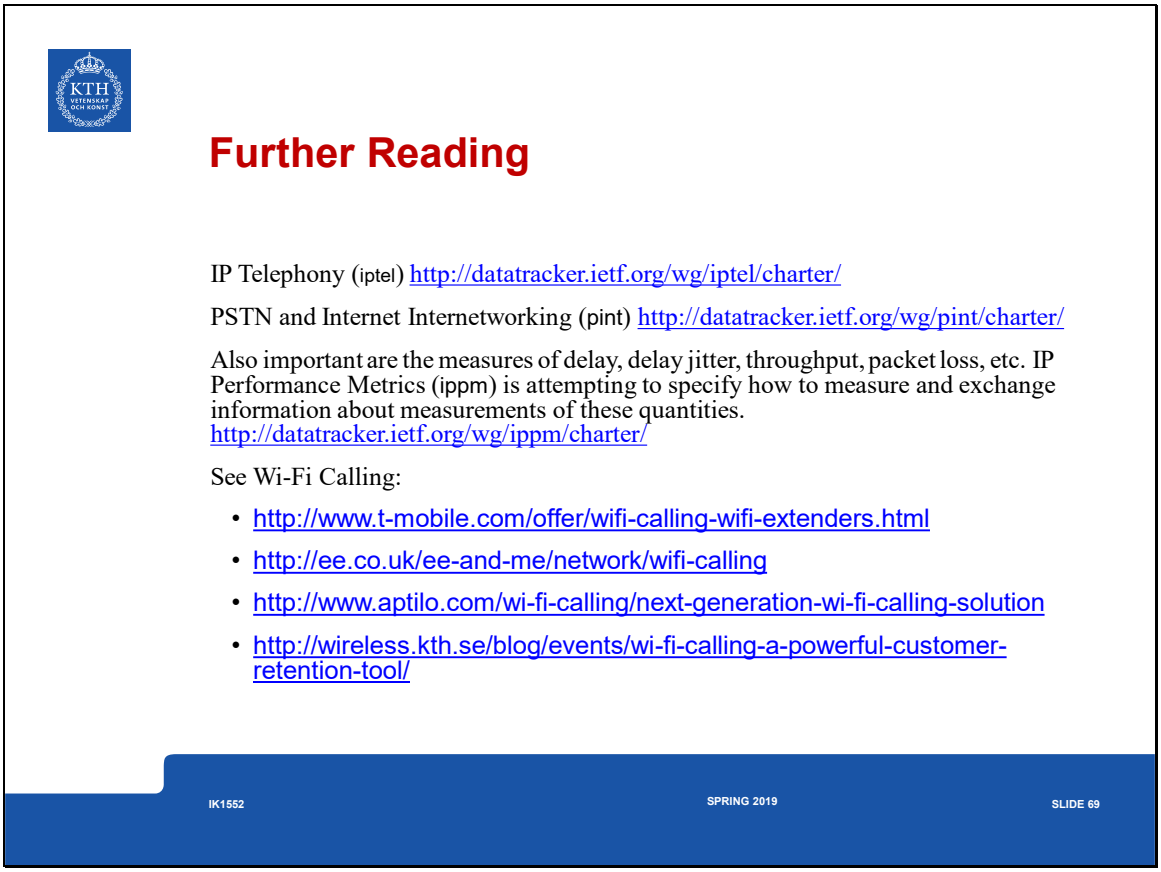
Further Reading
IP Telephony (iptel) http://datatracker.ietf.org/wg/iptel/charter/
PSTN and Internet Internetworking (pint) http://datatracker.ietf.org/wg/pint/charter/
Also important are the measures of delay, delay jitter, throughput, packet loss, etc. IP Performance Metrics (ippm) is attempting to specify how to measure and exchange information about measurements of these quantities.
http://datatracker.ietf.org/wg/ippm/charter/
See Wi-Fi Calling:
• http://www.t-mobile.com/offer/wifi-calling-wifi-extenders.html
• http://ee.co.uk/ee-and-me/network/wifi-calling
• http://www.aptilo.com/wi-fi-calling/next-generation-wi-fi-calling-solution
• http://wireless.kth.se/blog/events/wi-fi-calling-a-powerful-customer-retention-tool/
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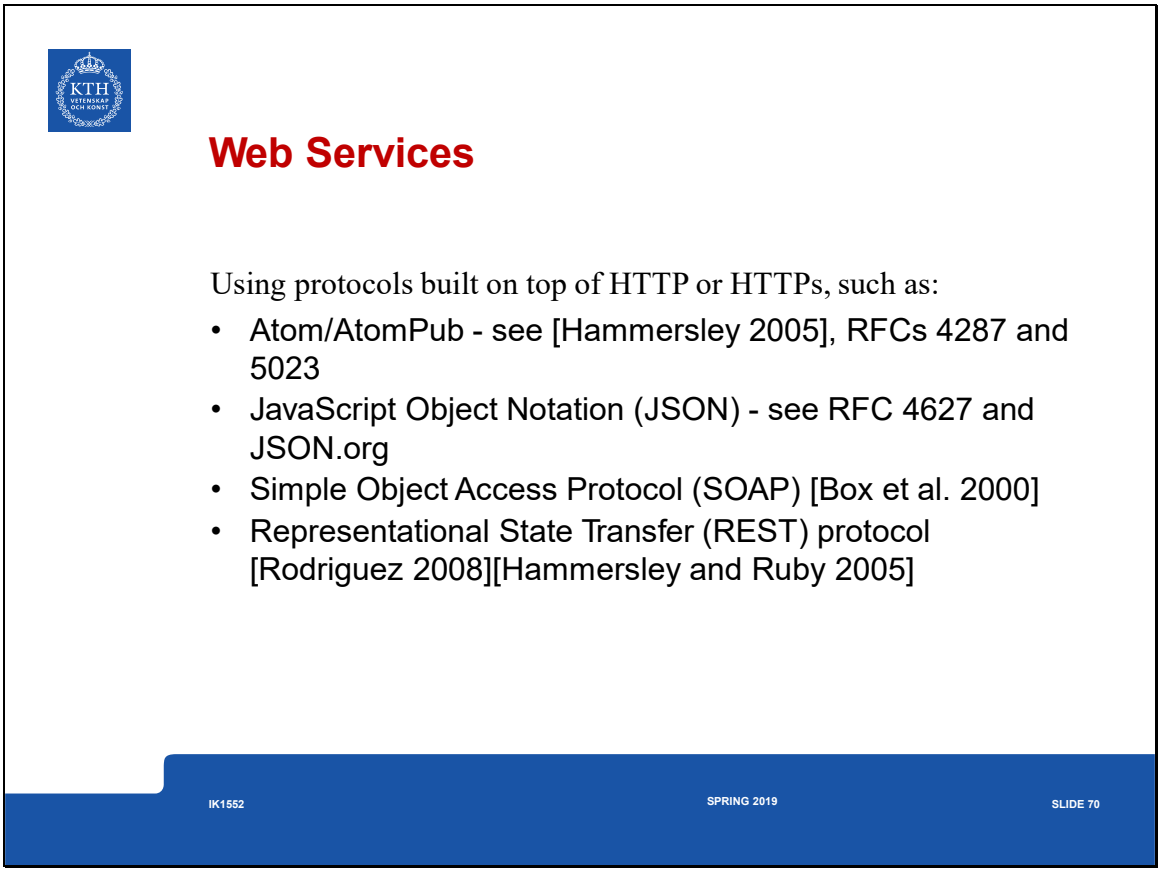


B. Hammersley, *Developing feeds with RSS and Atom*. Beijing ; Cambridge: O'Reilly, 2005, ISBN: 0596008813, 978-0596008819.

M. Nottingham and R. Sayre, 'The Atom Syndication Format', *Internet Request for Comments*, vol. RFC 4287 (Proposed Standard), December 2005, Available at http://www.rfc-editor.org/rfc/rfc4287.txt.

J. Gregorio and B. de hOra, 'The Atom Publishing Protocol', *Internet Request for Comments*, vol. RFC 5023 (Proposed Standard), October 2007, Available at http://www.rfc-editor.org/rfc/rfc5023.txt .

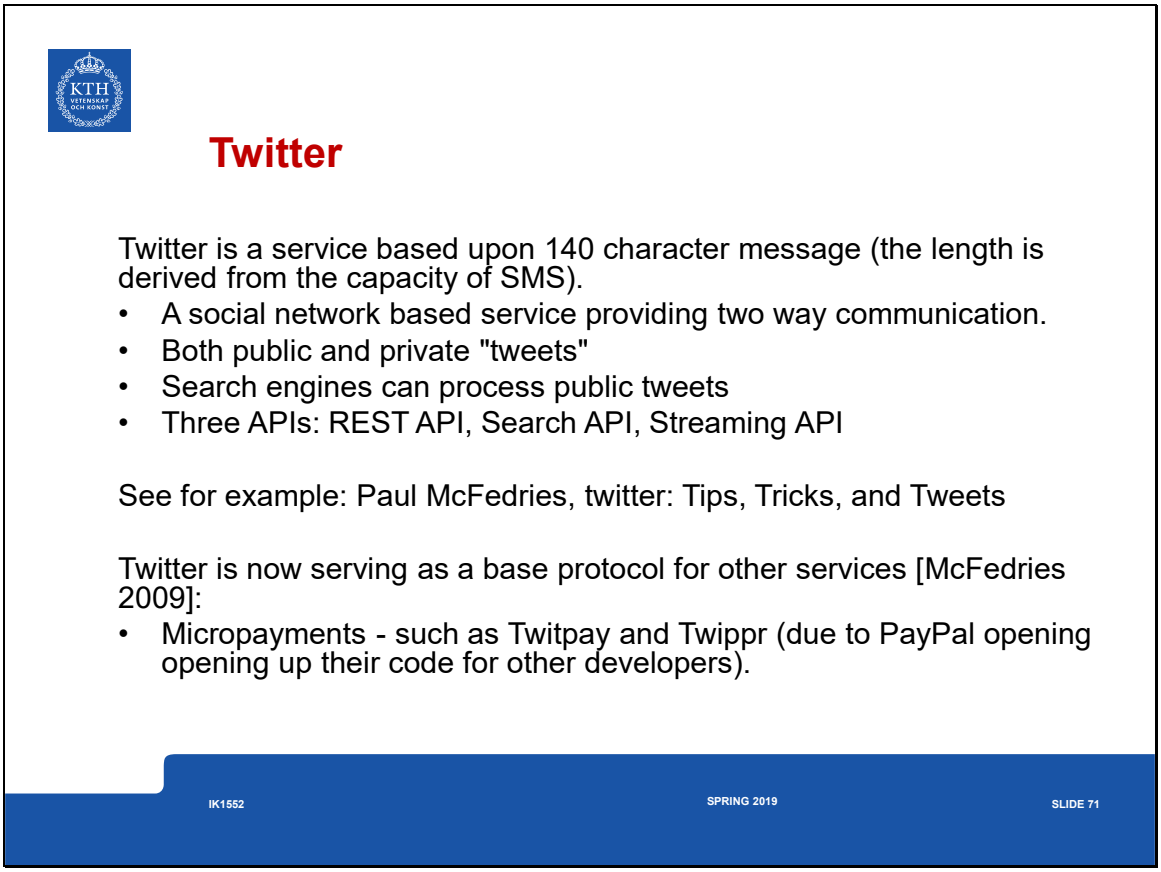
D. Crockford, 'The application/json Media Type for JavaScript Object Notation (JSON)', *Internet Request for Comments*, vol. RFC 4627 (Informational), July 2006, Available at http://www.rfc-editor.org/rfc/rfc4627.txt .

D. Box, D. Ehnebuske, G. Kakivaya, A. Layman, N. Mendelsohn, H. Nielsen, S. Thatte, and D. Winer, "Simple Object Access Protocol (SOAP) 1.1", May 2000. *http://www.w3.org/TR/2000/NOTE-SOAP-20000508*

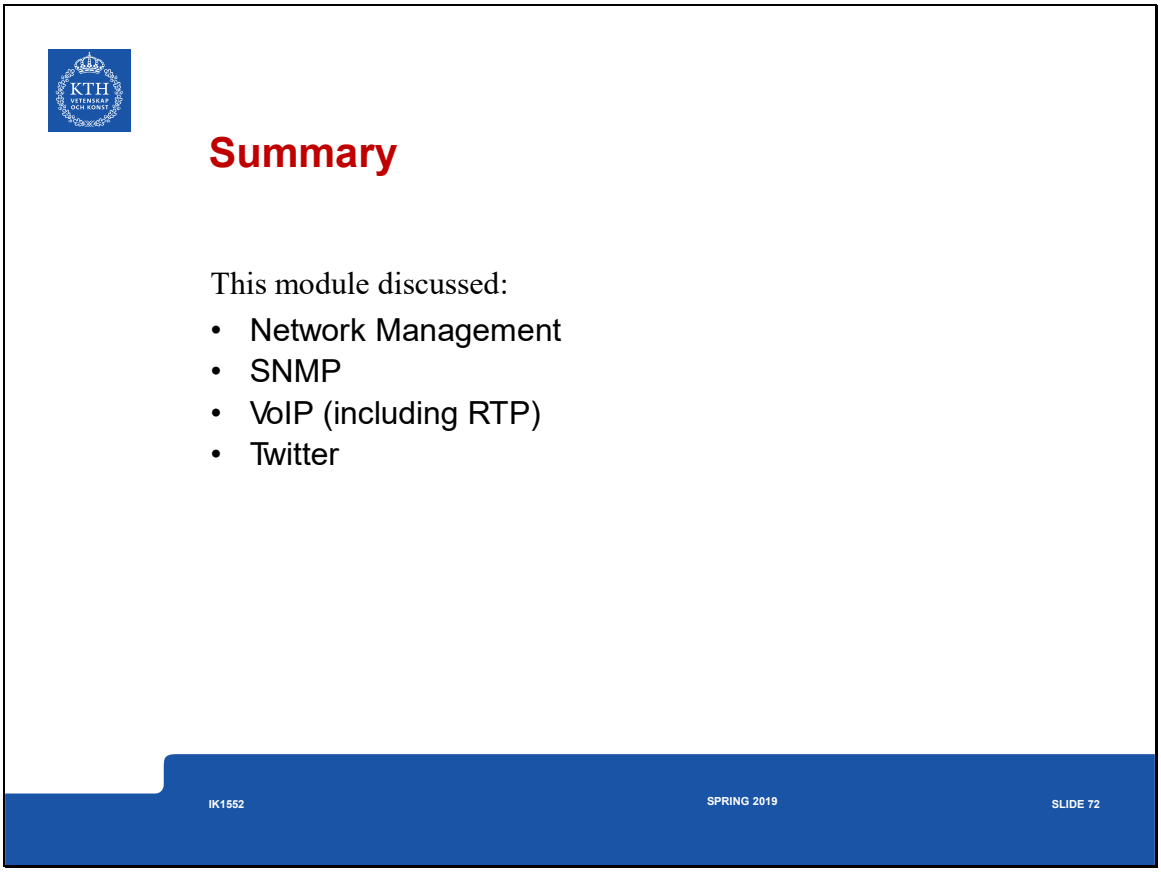
Alex Rodriguez, RESTful Web services: The basics, Web page, IBM, 06 Nov 2008 *http://www.ibm.com/developerworks/webservices/library/ws-restful/*

B. Hammersley and Sam Ruby, *Developing feeds with RSS and Atom*. Beijing ; Cambridge: O'Reilly, 2005, ISBN: 0596008813, 978-0596008819.

Slide 71



Paul McFedries, twitter: Tips, Tricks, and Tweets, Wiley Publishing Inc., 2009, ISBN 978-0-470-52969-0


Summary
This module discussed:
• Network Management
• SNMP
• VoIP (including RTP)
• Twitter
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