

TELE9752 Network Operations and Control

Session 2, 2017

Lecturer: Dr Tim Moors

Agenda

- Intro. to Network Operations and Control
- Course administrivia
 - Enough for now:
 - Slides are available on the course web page
<http://subjects.ee.unsw.edu.au/tele9752>
 - Slide IDs in bottom-left corner used in references
 - Tim tries to not talk too fast
 - Participate: Ask & answer questions
 - Bonus marks in lectures... [NZ>

Bonus marks in lectures

Hard for lecturer to remember who made what comment during lecture

=> Issue cards to people who participate well in lecture.

Blue = good, Green = better

See Lecturer after lecture to record last 3 digits of your student ID, e.g. z1234567





Outline

- NOC core images
- What is being managed
- Dividing the task (FCAPS, OAM&P) & division of labour
- Miscellany

Network Operations Centre glamour



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Image from http://www.research.att.com/areas/visualization/projects_software/photo_global_center.jpg

Others at <http://royal.pingdom.com/?p=296> NOC aka "Network Operations Center"

Other operations & control centres



NSW

Roads & Traffic Authority

“Transport Management Centre”



NASA's

Johnson Space Center's (JSC)

Mission Control Center (MCC)



Australian Dept. of Defence

Network Operations Centre

Figures from <http://www.rta.nsw.gov.au/trafficinformation/downloads/tmcbrochure.pdf>

http://www.nasa.gov/audience/formedia/presskits/ffs_gallery_mcc_image1.html

<http://www.defence.gov.au/defencemagazine/editions/200610/groups/cio.htm>

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Network Operations norm

Cubicle farm



+ Colocation centre (“colo”)



Images from <http://flickr.com/photos/kgibbons/953060828/>
and <http://flickr.com/photos/malfred/2517584165/>

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See also <http://arstechnica.com/business/2012/03/super-secret-google-builds-servers-in-the-dark/>
[Google Throws Open Doors to Its Top-Secret Data Center](#) and [Streetview](#)

NOC vs NM

- Typically NOC = Network Operations *Center*
- **NM = Network Management**
 - what is done at/from a NOC
 - so named in most written material, e.g. text books
 - Management can get very broad and fuzzy, very fast.
- This *course* focuses on management of technology, not management of people
=> “Network Operations and Control”
- This *lecture* outlines the broader context, including business/personnel aspects of NM



Outline

What should we operate & control?

Definitely:

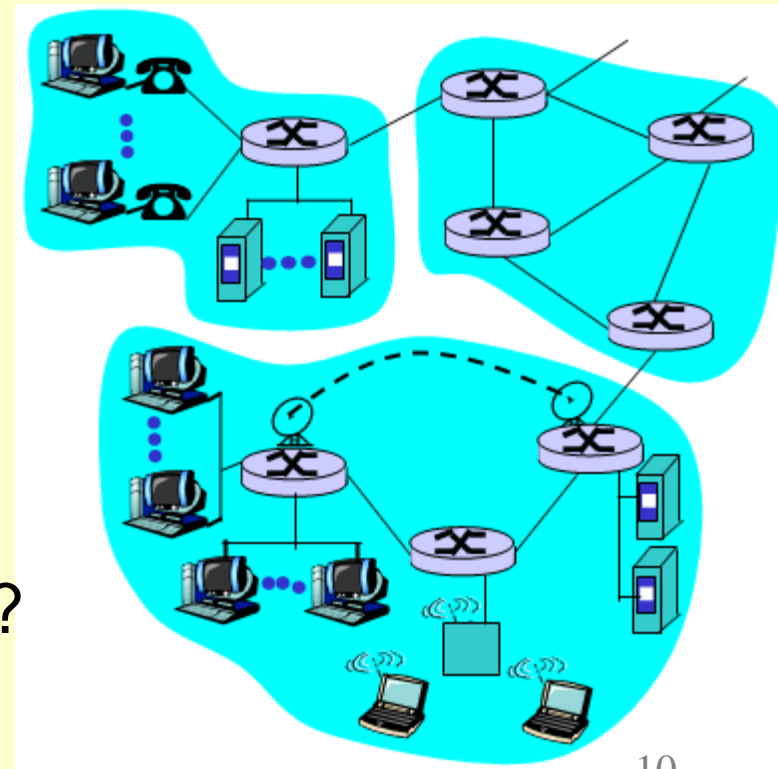
- **Network devices:** links, routers/switches
- **Network-centric services:** DHCP, DNS, firewalls, authentication, NAT, caches

Probably:

- **Servers** accessed through network: web, file servers, etc

Arguably:

- **Protocols on end-systems** (e.g. TCP)?
- **All IT systems**?!



NM entities 1

- **Network element**: Parts of the network that can be separately managed
 - i.e. hardware devices (e.g. routers) and modules (e.g. interface card) and software processes (e.g. Apache)
 - Not all network devices are manageable, e.g. wiring closet, dumb switch.
- **Managed object** [UR>: A representation of an aspect of an element that can be managed
 - e.g. IP address & default TTL, count of packets received
 - **MIB (Management Information Base)** – a collection of related objects, e.g. IP-MIB of objects relating to implementations of the Internet Protocol

NM entities 2

- **Management agent:** Software on element that enables management
 - Implements protocols such as the **Simple Network Management Protocol (SNMP)**
- **Network Management System/centre (NMS/NMC):**
Manages objects through agents; often based in a NOC
May offer the Manager a Command Line Interface (CLI) (e.g. [WJ>) or Graphical User Interface (GUI)
- **Manager/Mgr:** a person; manages the network, not (necessarily) other people, aka “network administrator”
- **Services:** What users directly care about.

Rising levels of abstraction

ITU's Telecommunications Management Network (TMN) model defines several Management Layers [M.3010]:

- **Business ML**: Manage workflow & monetary aspects
- **Service ML**: Manage all elements to provide a desired service, e.g. VOIP for some user
- **Network ML**: Manage a group of elements; e.g. address numbering plan
- **Element ML**: Manage individual elements
- **Network element**: Provides the service, e.g. router, link, web server process

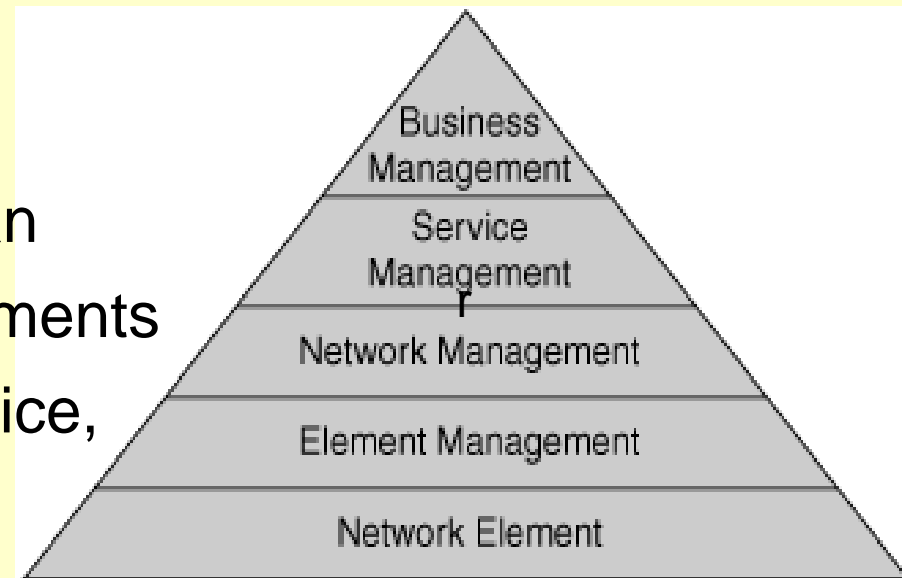


Figure from [Clemm]

“Network Management” here == managing the network rather than elements != NM elsewhere e.g. <V7]

For a tutorial on TMN, see <http://www.simpleweb.org/tutorials/tmn/index.html>

Note that the “Element Management” layer involves managing individual elements, whereas “Element Management Systems” [<http://www.iec.org/online/tutorials/ems/>] involve managing multiple elements.

Management interfaces

- **Element management:**
 - Direct (manager to element)
 - Command Line Interface
 - Web interface – hosted on the device
 - **Indirect:** (via protocols) e.g. SNMP, syslog
- **Network management:**
 - NMS; Nagios & MRTG
 - Configuration databases
- **Service management:**
 - Operations Support Systems
 - Trouble ticket systems [JW>

SNMP in a nutshell

Allows a manager (or Network Management System) to exchange information with a network element in a standard way (c.f. proprietary CLIs/GUIs)

Information is held in “objects” <7D]

Main functions:

- **Get** the value of an object.
- **Set** the value of an object.
- **Trap**: Get notified when something happens

Later: Full lectures about objects [9N> and SNMP [U8>



Outline

NM vs network tech courses

Network technologies courses (e.g. TELE3118) describe how networks work to deliver payload for users.

- What happens **when things go wrong**? Faults (F)
- **Assumes network already exists** - how was it planned, installed, configured for local conditions? (C)
- **Who pays**/paid for it? Accounting (A)
- Need to **monitor performance**, e.g. to inform planning, detect faults, etc? Performance (P)
- **How is it secured** (e.g. against fraud)? How is security configured? Monitoring to detect security events? (S)

=> (F)(C)(A)(P)(S)

Management Functional Areas

The CCITT (now ITU) defined 5 “functional areas” for managing OSI systems: “FCAPS” [X.700]:

- **Fault management:** Detect, isolate and correct abnormal operation
- **Configuration management:** Set parameters that govern behaviour
- **Accounting management:** Enable charging for resource use
- **Performance management:** Measure and record system behaviour
- **Security management:** “support the application of security policies”

OSI = Open Systems Interconnection = alternative to TCP/IP model from 1980s

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OAM&P

FCAPS covers most *tasks*, but *organisational* substructures (needed for larger telcos) tend to differ

OAM&P is often used (but scantily defined[†]):

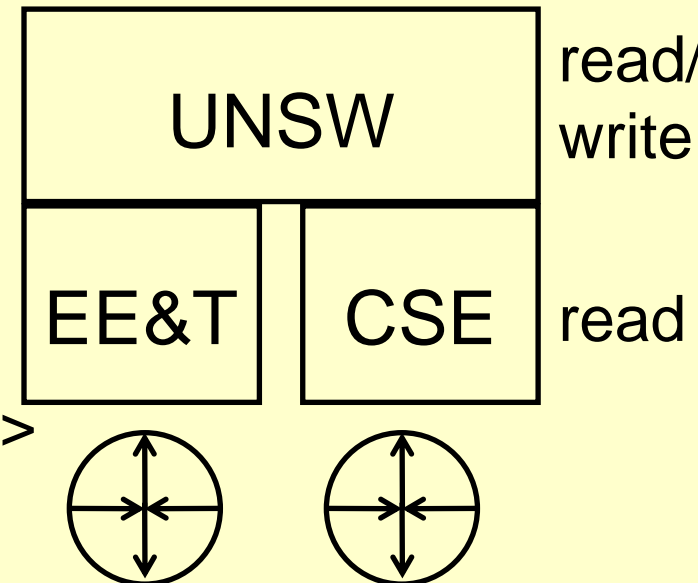
- **Operations**: Monitoring and detecting faults (F)
- **Administration**: Monitoring traffic for billing (A) & capacity planning (P)
- **Maintenance**: Installation, configuration(C) & fixing faults(F)
- **Provisioning**: Planning & design (based on P), set up service for new users (C,S)

Multiple managers

Multiple managers support:

- specialisation in different technologies, e.g. web vs fibre
- 24x7 need for network management (vs “40hour” work week)
- volume of work
- particular customer groups, e.g. local service may be quicker to arrive or take responsibility for customer

=> Managers may vary in their access to objects. Restrict access with “views”[73]>



Tiered technical support

Managers often form a hierarchy with stronger skills at higher levels.

Level 0/1 faces customers: lowest skill: cheaply deal with common cases

Requests/incidents needing extra skill “escalate” to a higher level.

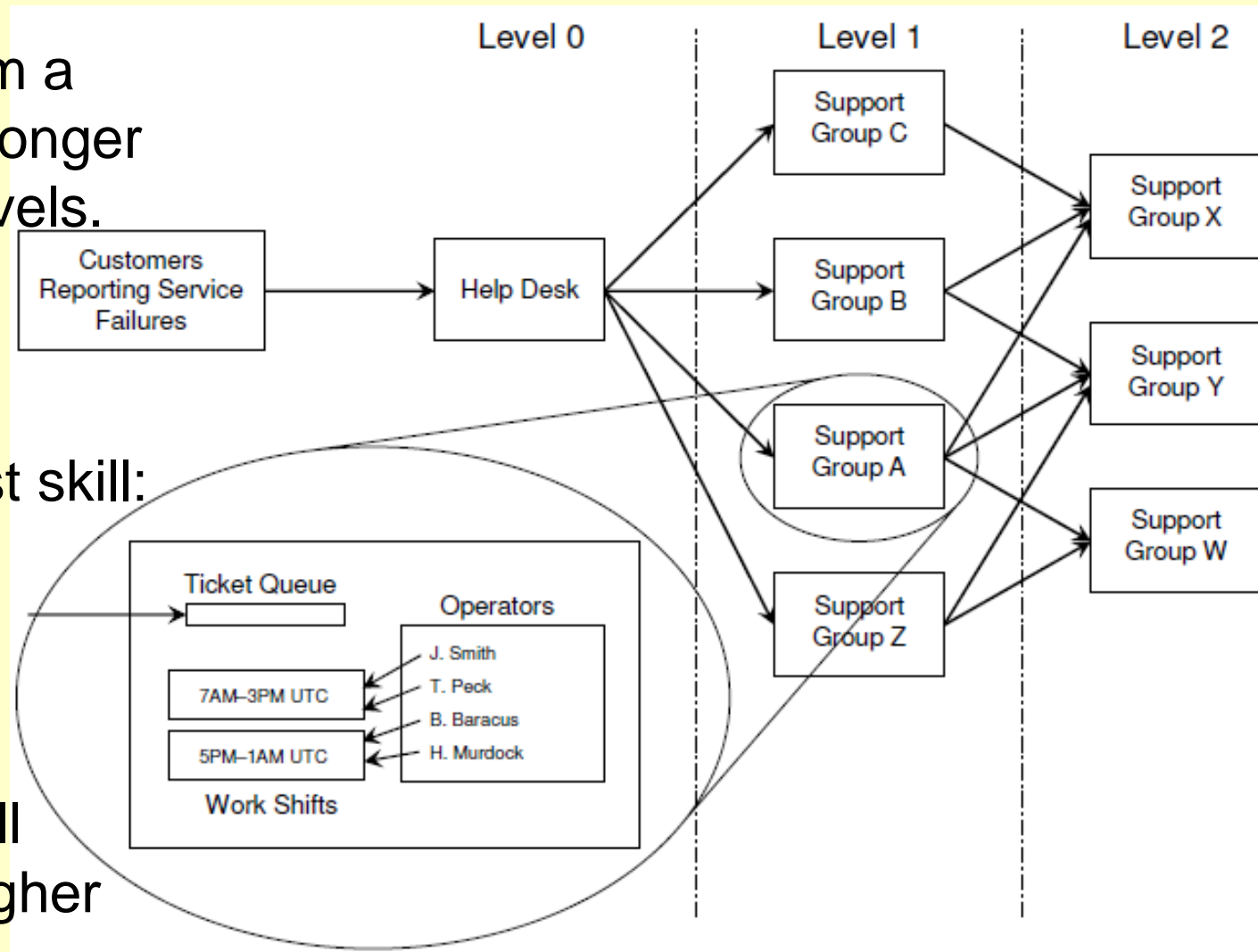


Figure from “[SYMIAN: Analysis and Performance Improvement of the IT Incident Management Process](#)”

“higher” = “further to right” in this figure. Think of it rotated anticlockwise by 90 degrees.

Operations Support Systems (OSS)

- = Systems (often software) to automate and coordinate network operation tasks
 - Covers higher levels of TMN model (service & business management) as much (if not more) than NM.
- The TeleManagement Forum (TMF) is developing a “New Generation Operations Systems and Software” (NGOSS)
- Local OSS developers: www.clarityint.com & previously fastwire-group.com & elantisystems.com

For a (somewhat dated) tutorial on OSS, see <http://www.iec.org/online/tutorials/oss/>

Business Support Systems (BSS) focus on customers, e.g. accepting orders, sending bills

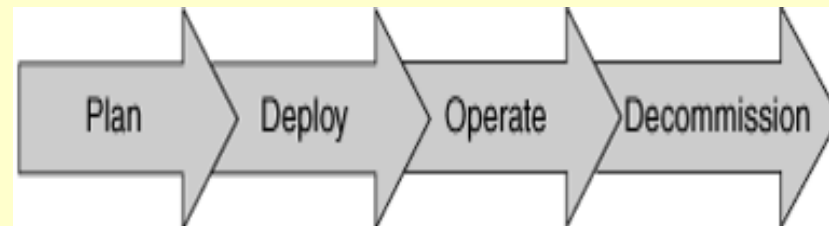
24A & receiving payments.



Outline

Lifecycle of network management

"Intuitively, network management encompasses tasks associated with planning, deploying, configuring, operating, monitoring, tuning, repairing, and changing computer networks." - D. Comer, p. 26



i.e. like “NM vs network tech courses” slide <QP]:
NM = everything needed other than the running network.

NM = the manual stuff?

“network management is best described as *all the aspects of devising and operating a network that no one knows how to automate.*” - in D. Comer:

Automated Network Management Systems, p. 26

- NM usually involves human intervention
- But technology can improve human productivity
 - e.g. DHCP, SNMP, root cause analysis software...

Man vs machine

Automated systems:

- Don't introduce human errors (at least during operation, if not during design)
- Respond faster
- Reduce labour costs

But

- may not be customised for local conditions
- can be complex/difficult to understand (e.g. disable STP)
- may hide useful info (e.g. network becoming brittle and about to partition)
- *may* not match human judgement

Why NM/NOC is challenging

- **Complex:** Communication networks are complicated and change rapidly. Information hidden to ease design may be needed for debugging.
- **Distributed** systems are hard to control: unsynchronised and inconsistent state. Fault management systems must work when the rest of the network doesn't.
- **Internet**
 - pushes functionality to ends, away from NM reach
 - collection of Autonomous Systems => heterogeneous & many responsible parties
- **Vendor competition:** Users want it, vendors don't

network + “management” but not NM

Any issue can be “managed”, but NM doesn't cover *all* network issues, e.g.

- Power *management*, e.g. mobile device use of WiFi
- Link *Management* Protocol [RFC 4204] - part of GMPLS/Bluetooth
- Active Queue *Management* [TELE9751]
- Mobility *management* and location *management*
- Internet Group *Management* Protocol
- Traffic *management*
- Key *management* (e.g. ISAKMP)

Network Management standards

- **ISO/OSI**

- Common Management Information Services & Protocol
 - Same issues & fate as OSI Reference Model

- **IETF**

- SNMP, syslog, IPFIX, NETCONF/YANG etc [[RFC 6632](#)]

- **ITU**

- X.700: FCAPS for OSI management
- M.3000: Telecommunications Management Network

- **Distributed Management Task Force** ([dmtf.org](#))

- Manage distributed computing systems

- **Others:** TMF(NGOSS), tech bodies: IEEE, Broadband Forum...

History of Network Management

- **Originally:** Network designers = operators + small networks => manual NM
- **1970s:** phone companies develop OSS, CCITT X.700
- **1980s:** Data networks appear
 - OSI CMIP vs IETF SNMP
 - Cisco IOS
- **1990s:** Heterogeneous networks
 - vendor-neutral NMS, e.g. HPOV & IBM Tivoli
- **21st century:**
 - open source software (e.g. openNMS, Nagios)
 - Software Defined Networking

Agenda

- Intro. to Network Operations and Control
- **Course administrivia**

Ad break

Want to do a thesis/project on networking, e.g. as part of a BE, MEngSc(Ext) or ME degree?

Several in the *broad areas of “software defined networking”, “network reliability” and “named data networking”*

See Moodle & <http://www2.eet.unsw.edu.au/~timm/thesis.html>

You must have done well in networking course(s), possibly have industrial experience & be confident programming

Email resume and academic records to

t.moors AT unsw.edu.au ASAP (definitely by end of week 1)

Administrivia

- Aims
- Assessment

The aim of this course

The aim of TELE9752 is to develop student understanding of how telecommunication networks are operated and controlled. That is, whereas other networking courses focus solely on the technologies that enable users to transfer information across a network (e.g. TELE3118 focuses on network protocols, and TELE9751 focuses on the design of network equipment), this course considers how such technologies can be operated and controlled by people concerned with service provision (e.g. network administrators).

Assessment

80% Exams

35% mid-session exam

45% final exam

10% Assignment

10% Group research [HN>

+

up to 10% Bonus marks for course improvement/participation

Unfortunately no practical exercise this year due to building refurbishment.

Group research

- Aims:
 - information literacy: Accessing latest NOC advances
 - experience collaboration
 - develop communication skills
 - exposure to content: 1 aspect in depth + intro to several aspects
- 3 hours @ 12min/pres + 3min? + 2 x 12min breaks
= 24+ students / 6 papers => groups of about 4
(Might ↑ members to ↓ groups to ↑ time/paper.)
- Groups to be allocated in week 3, after enrolments stabilise.
- Product (not process) will be assessed => specialise according to skills/interests.
- Teamwork review around week 9

How assessment relates to course aims

- The bulk (80%) of assessment (exams)
 - consists of individual tasks, ensuring that it assesses the extent of *your* learning.
 - tests “in-depth engagement with the relevant disciplinary knowledge”
- Exercise to assess practical application of knowledge (temporarily replaced by assignment due to building refurbishment)
- Group research to develop information literacy and collaborative & communication skills

Continual course improvement

- Solicitation of suggestions
 - Add comments to the “[Suggestions for improving the course](#)” Moodle forum
 - in person
 - You can receive bonus marks for constructive suggestions!
- Action on past suggestions
 - Tim trying to talk slower. May record audio for final slides in lecture if run out of time during class.

Textbooks

- Still searching for a highly recommended text!
- Recommended:
 - A. [Clemm](#): *Network Management Fundamentals*, Cisco Press
- Many others in the library
 - References in slides may reflect convenience rather than quality.

Things to think about

- **Critical thinking:** If FCAPS & OAM&P are 2 ways to divide the tasks, might there be other (better) ways?
- **Engineering methods:**
 - Tiered support <JW] is an example of minimising costs by using the cheapest solution possible for each task.
 - The NM lifecycle <J1] is like that of other engineered systems.
- **Links to other areas:**
 - Management centres for transportation, space etc systems
 - FCAPS equivalents in other engineering fields
- **Independent learning:**
 - [“Network Management Challenges and Trends in Multi-Layer and Multi-Vendor Settings for Carrier-Grade Networks”](#) surveys recent (2014) issues

The end

Ad: Supervision available for thesis projects

Outline of NOC intro slides

Numbers & identifiers identify slides which cover each topic

Imagery of NOC core

- 4 QA glamour
- 5 W8 Control centres in other fields
- 6 CA reality

Context

- 5 W8 Control centres in other fields
- 8 V7 NOC vs NM
- 13 QP NM vs network tech courses
- 23 L8 network + “management” but not NM

12 0Q Business aspects of NOC

What is involved

- 7 1L What should we operate & control?
- 9 7D NM entities 1
- 10 F3 2
- 18 4A Operations Support Systems (OSS) ←
- 20 XM NM = the manual stuff?
- 21 TW Man vs machine

Ways of dividing the problem

- 11 XT Rising levels of abstraction
- 14 2W Management Functional Areas
- 15 6A OAM&P
- 16 TX Multiple managers
- 17 JW Tiered technical support
- 19 J1 Lifecycle of network management

Misc

- 22 3W Why NM/NOC is challenging
- 24 R2 Network Management standards
- 25 UK History of Network Management