Project Management for Telecommunications Services

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Overview of the Tutorial

- Why project management in telecommunications services?
- Innovation and standardization
- Organization
- Scope Management
- Risk Management
- Quality Management
- Concluding remarks

What is Project Management ?

- A project is a temporary endeavor undertaken to create a unique product or service
- Project management is the application of knowledge, skills, techniques and tools to meet project goals and
  - balance competing needs on scope, time, and quality
  - meet customer's requirements and expectations
  - satisfy the various stakeholders
- Used first in construction, then in defense, chemical and pharmaceutical industries, software development etc.

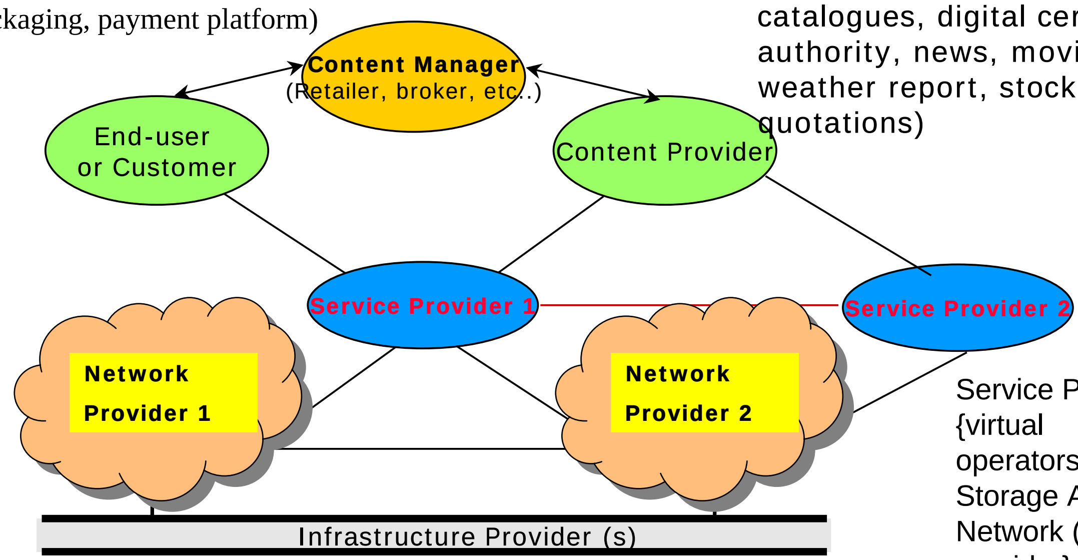
Project Management in Telecommunication Services

- Infrastructure projects take several years and involve several thousands of individuals
- Telecommunication companies are no longer vertically integrated; many entities need to cooperate
- Interfaces are very complex especially with outsourcing
- Regulatory and technological changes have promoted unbundling of telecommunication services”
- Product must fit existing organizational and technical interfaces (backward compatibility)

Architecture of Telecommunications Services

Content Manager (Customer Relationship Manager, content packaging, payment platform)

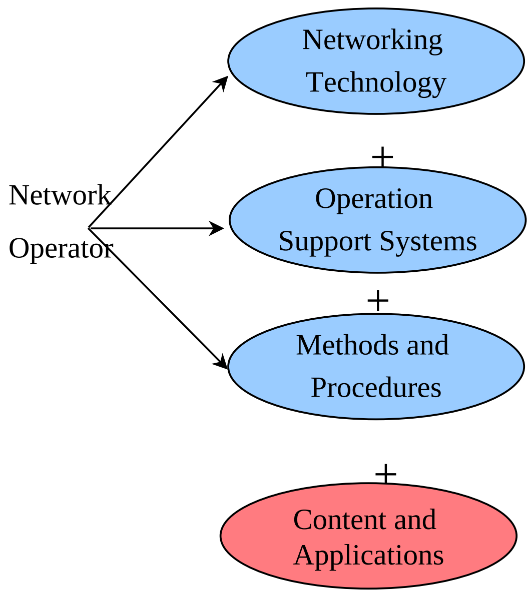
Content Provider (Call center, catalogues, digital certification authority, news, movies, weather report, stock quotations)



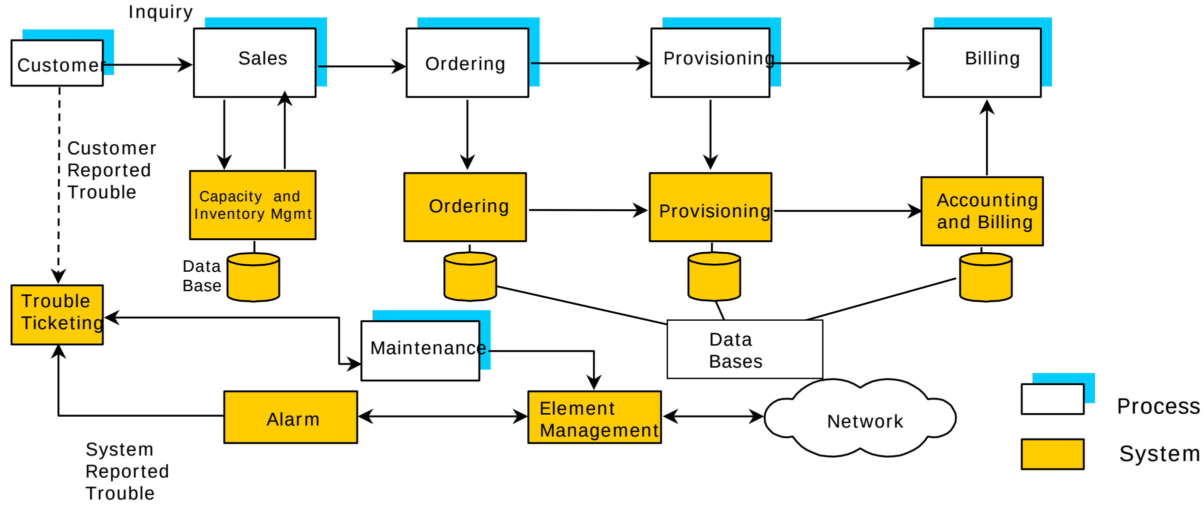
Service Provider {virtual operators,ISP, Storage Area Network (SAN) provider}

The Two Sides of Telecommunication Services

- External view: a set of networking services available to subscribers
- Internal view: networking technologies, operation support systems, methods and procedures, applications and content distribution



Internal Interfaces



Functional Aspects of Telecommunications Management

- Configuration management
- Fault management
- Performance management
- Security management
- Accounting management
- Billing
- Fulfillment (post-sale activities)
- Standards are needed (ITU, ATMF, IETF, etc.)

Billing Systems

- Recovering cost
- Uncovering new business opportunities
- Customer relationship management (CRM) systems rely on billing records to understand user's profile
- Interconnect billing systems keep track of the flow of traffic between to different network operators
- In the U.S., FCC mandates that revenues from long distance communications be shared.
- Revenue loss from inaccurate or incomplete records

Examples of Telecommunications Projects

- Replace obsolete technologies
  - Replacement of 1A processor with the 1B process in the 4ESS switch without downtime nor service interruption over 135 sites during the 1990's
  - Satisfy new regulations (local number portability)
- Add new capacity to meet growth
  - numbering changes (adding new area codes or changing the numbering schemes)
  - migration of existing traffic to different facilities (e.g., a new undersea cable)
  - Dense wavelength division multiplexing (DWDM) equipment to augment bandwidth in WANs

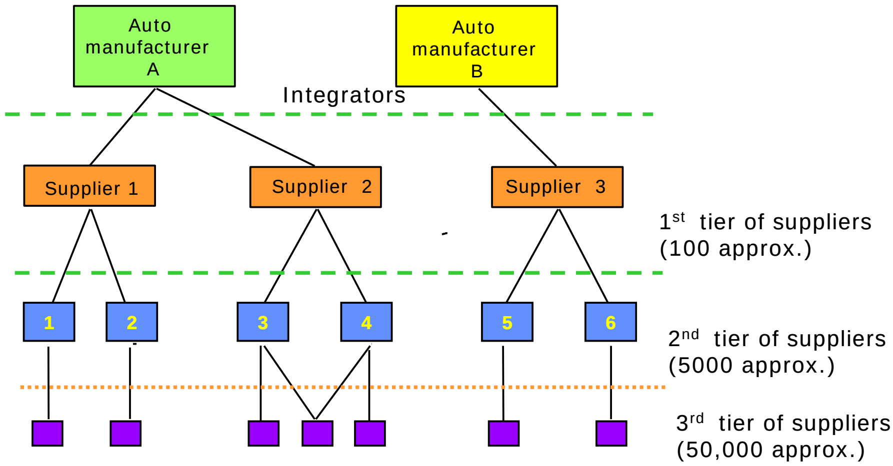
Temporary Installations

- Several networks for a specific event or a major international conference or for relief operation
- The operational date is absolutely fixed and must be met at any cost
- The purpose is to provide access to the outside world and internal communication among the participants
- Variety of access media (fixed-wire, mobile, radio, TV, satellite, etc.)
- Local networks must integrate gracefully with other national (emergency, hospital and police services) and international networks
- The size can be very large (12 million telephone calls during the Olympics)
- The project tasks cover planning, installation, deployment, operation and dismantling

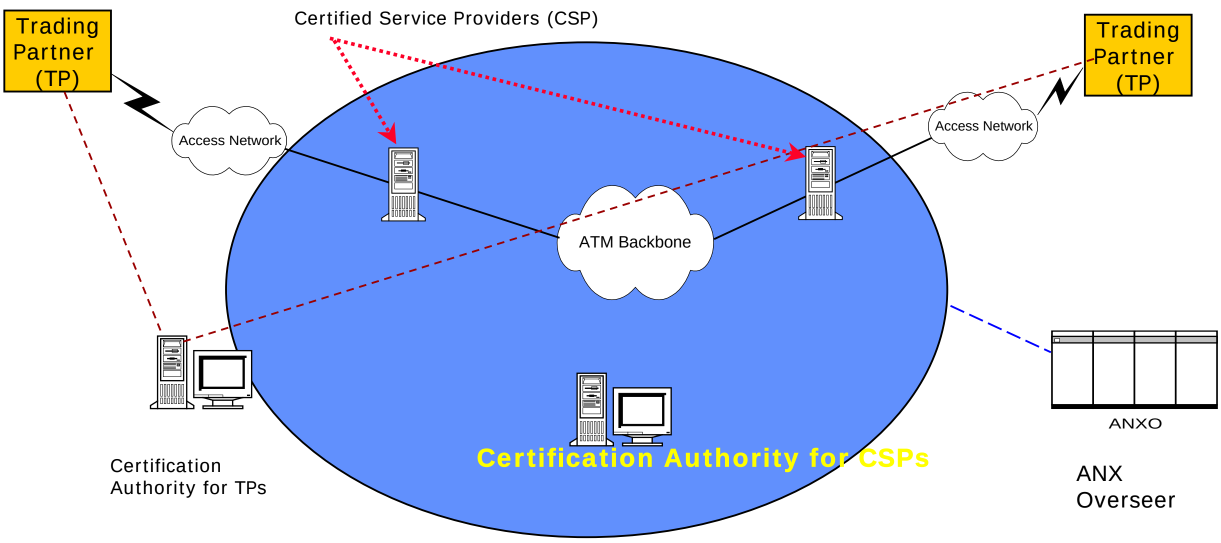
Examples in Business Networks

- Introduce new applications
  - Call Centers
  - Customer Relations Management
  - Payment systems
  - EDI/XML interface
- Establish specialized networks
  - Automotive Network Exchange (ANX) for the North American auto industry

Organization of the Auto Industry



Automotive Network Exchange (ANX)



Planning for Telecommunication Services

- Very long planning period even for temporary projects
- Training of personnel (help desk, maintenance, etc.)
- Dismantling is important (90% of installed equipment has to be dismantled in temporary projects)
- Due to environmental consideration, location of antenna towers, recycling of refuse, etc.
- Environmental issues: for example timing point electrical boxes suitable for harsh environments

Example: Installation of Undersea Cable

- Teams from several companies collaborate on the specifications, selection of equipment vendor and the network architecture
- Purchasing, installation and testing of submarine cable terminal equipment
- Establishment of financial and accounting procedures within the various partners.
- Supplier's management through contracting
- Definition of pricing and billing structure

International Dimension

- Telecommunication services projects are usually multi-country and multi-company projects
- Global companies need "global carriers“ to avoid account settlement and payment with different currencies.
- Making a global service is difficult because:
  – Regulatory and licensing requirements vary
  – Availability of services and their reliability depend on the country
  – Vendor support is not the same in every country
  – Account settlement and payment with different currencies poses challenges
  – Difference in legal systems concerning content ownership, rights to privacy, what is a service level agreement, what type of encryption is allowed, responsibility of the carrier with respect to the content

No Mass Production

- Telecommunication services take place in a specific environment
- Factors affecting variety
  – The type of network used (public, private, virtual private), etc.
  – Target market (consumers, business, government, military, service resellers, etc.)
  – Nature of the installation (permanent or temporary)
  – Types of services
  – Legal framework

Characteristics of Telecommunications Projects

- Complex Interfaces
  - Internal
  - with equipment vendors
  - with other network/service providers
- International Dimension
- Relatively long planning stage (even for temporary installations)
- Multiple functional aspects
- No mass production
- Diversity of user requirements

Disciplines Involved in Telecommunications Projects

- Engineering: construction, physical design, mechanical, electrical, software and thermal engineering, operation planning, quality assurance, environmental
- Risk analysis
- Administrative
- Disaster recovery, etc.
- Legal
- Marketing

Comparison of Telecommunications Projects (equipment Vs. service)

Item	Telecommunications Manufacturer	Telecommunications Service Provider
Participants	Manufacturing, marketing, research and development, environmental	Administrative, legal, construction, quality assurance, marketing, environmental
Production	Mass production	No mass production
External Interfaces	Supply management for individual component, customer management (consumer or another business)	Supplier management for bandwidth and equipment, customer management depends on the business model Internal interfaces to OSSs
International dimension	Optional - Mostly for marketing and regulatory aspects	Marketing, regulation, interconnectivity , account settlement, payment, trouble isolation and repair, vendor support, etc.
Quality criteria	Cost, size or foot-print, power consumption, reliability, ease of repair, etc.	Cost, availability, reliability, billing accuracy, customer support, etc..

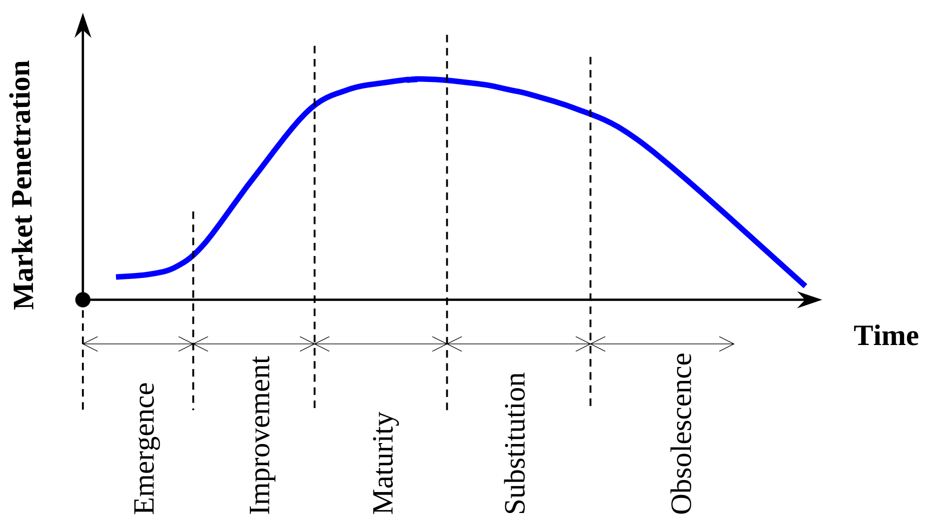
Problems in Telecommunications Project Management

- Coordination among all parties, given the interdependencies, and the high degree of technological, environmental and market uncertainties. This may lead to complex and costly communications, to excessive bureaucracy or both.
- Absent end-customer, which makes application of quality techniques more difficult
- Transmission of acquired knowledge to successive or concurrent projects with an unstable environment

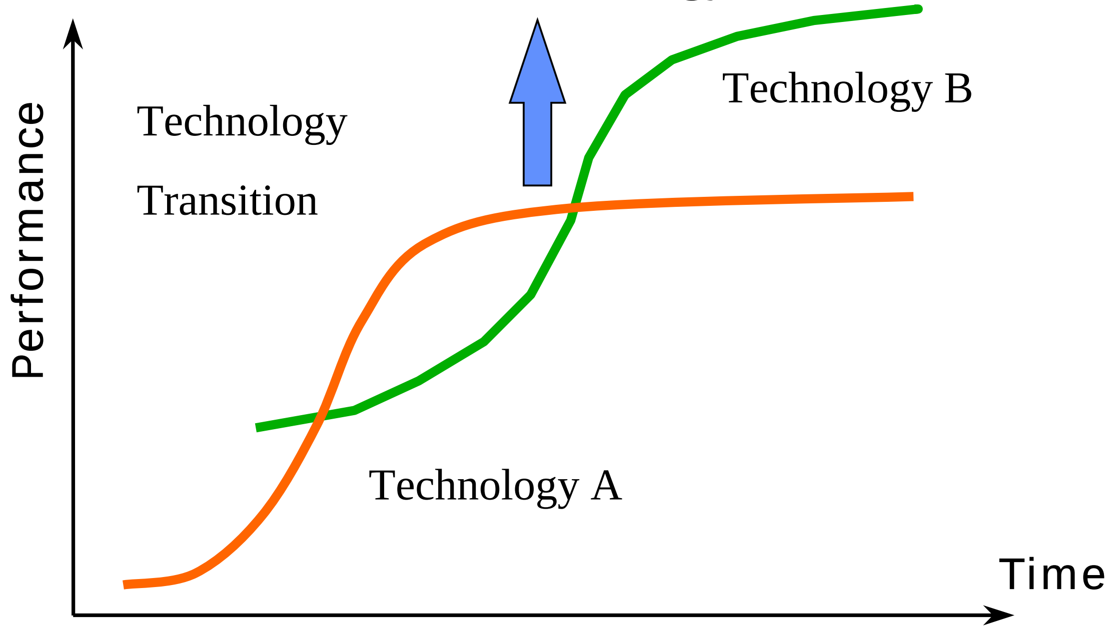
Innovation and Standardization

- Telecommunication projects build on a technical infrastructure to meet business and social objectives
- Service customization introduces new criteria for evaluation other that the performance of technology
- Need to combine two views: technological and marketing to position products and services
- Insights from management of innovation can be useful

The Technological Dimension:
Technology Life Cycle



S-curves for Technology Succession



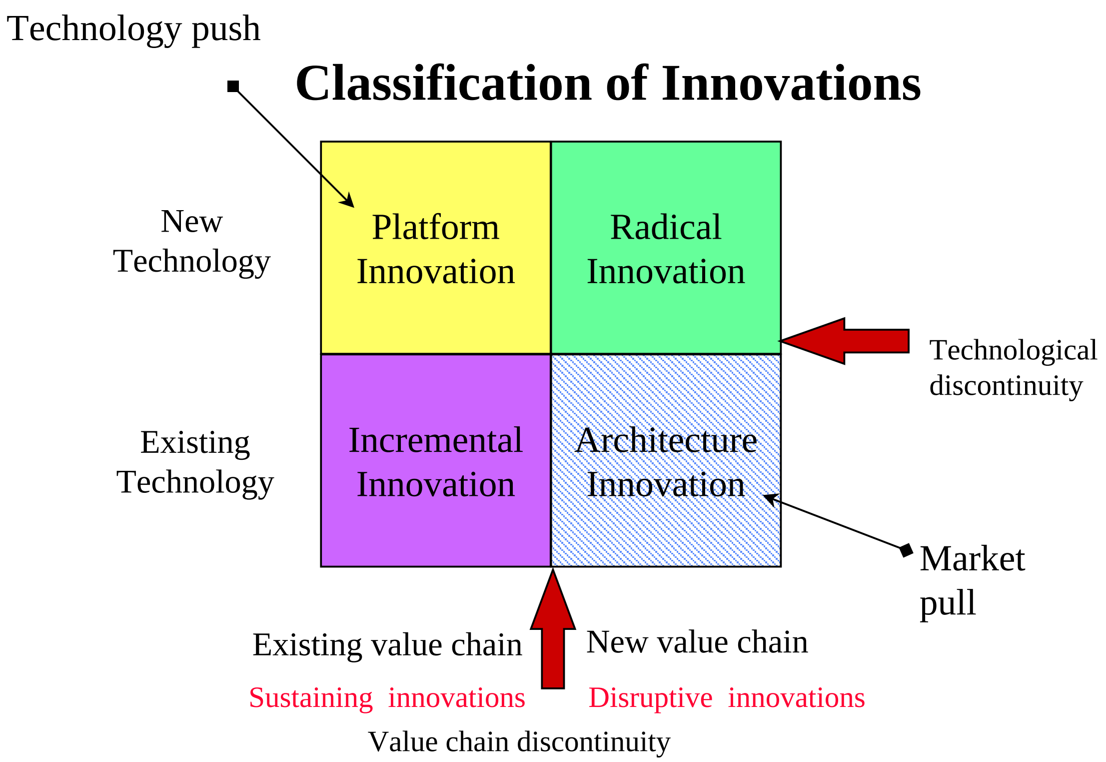
Changes due to Technology Transition

- New Network elements and network elements management systems
- New technical and development process including the production system
- New Skills (technicians, technical staff, management)
- Different supply chain (vendors, acceptance testing procedures, intervals, etc.)
- Capital expenditures (new type of equipment, facilities, inventories)
- New terminology, knowledge and expertise

Marketing and Social Dimension

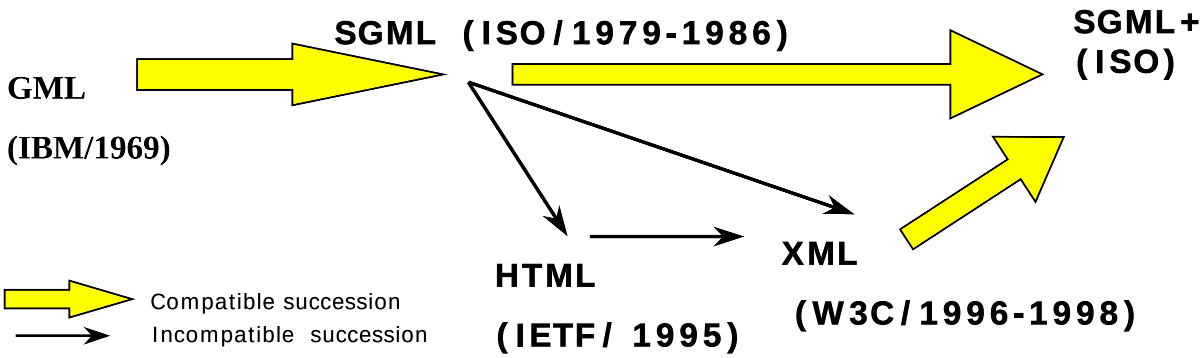
- Use the concept of a **value network** to represent the context within which a firm operates
- Participants in a value chain use a set of attributes for evaluation
- A value chain discontinuity takes place when the nature of the attributes or their order change (e.g., the criteria to ranking the subjective quality of speech call depends on whether mobility is considered). Similar to Kuhn's paradigm shift in science
- A value chain discontinuity affects the following:
  - Customer groups and markets
  - Customer applications
  - Channels of distribution and service delivery
  - Customer knowledge
  - Modes of communication with customers

Classification of Innovations

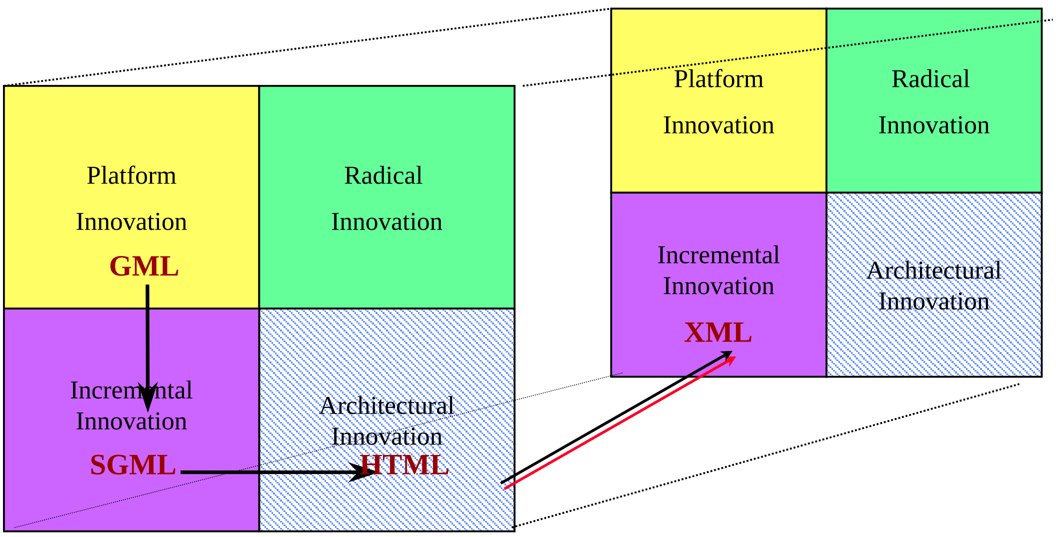


Examples

- Incremental: SGML from GML, XML from HTML and SGML
- Architectural: HTML from SGML



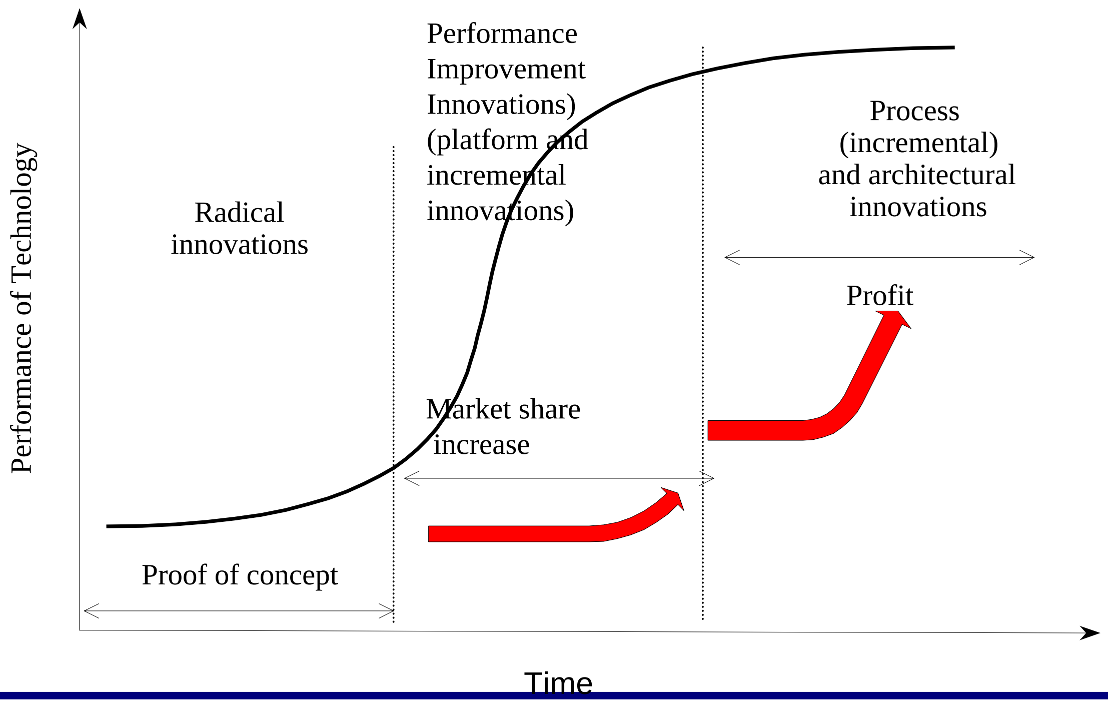
Succession of Innovation Types From GML to XML



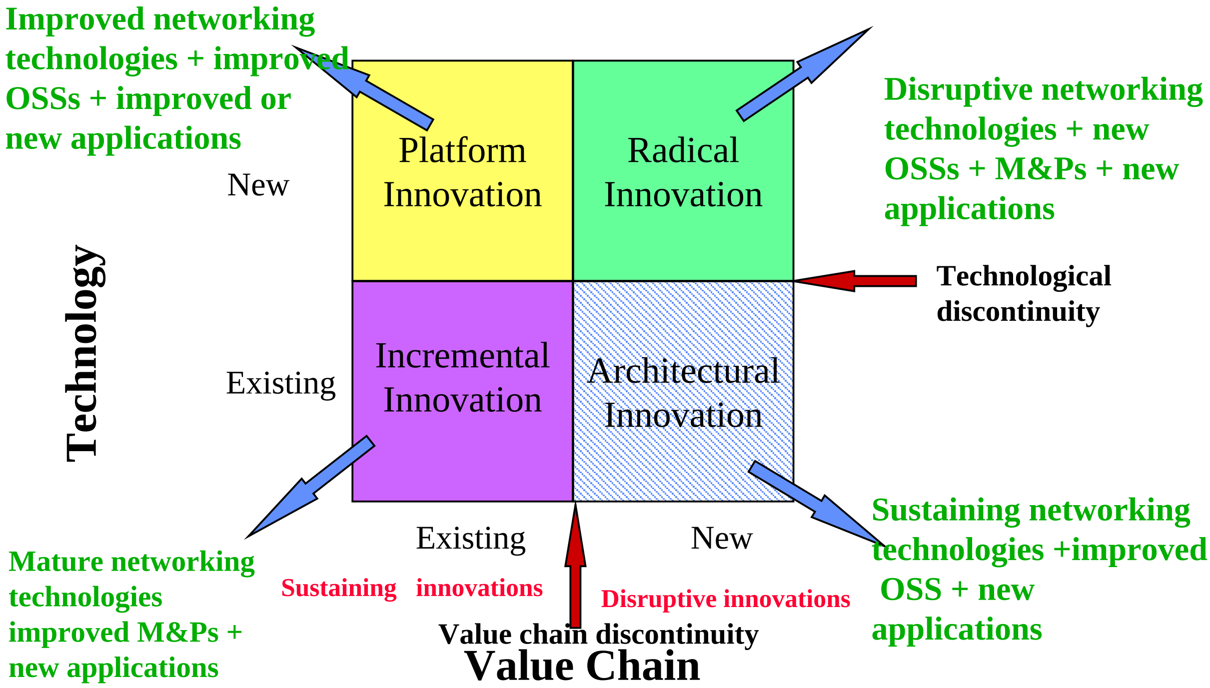
Radical Innovations

- Rare (Thomas Kuhn: *The structure of scientific revolutions*)
- Uncertainties
  - Technical
  - Resources
  - Organizational
  - Market
- Deming: "New products and new types of service are generated, not by asking customers, but by knowledge, imagination,innovation, risk, trial and error on the part of the producer, backed by enough capital to develop the product or service and to stay in business during the lean months of introduction".

Innovation and the Technology Cycle



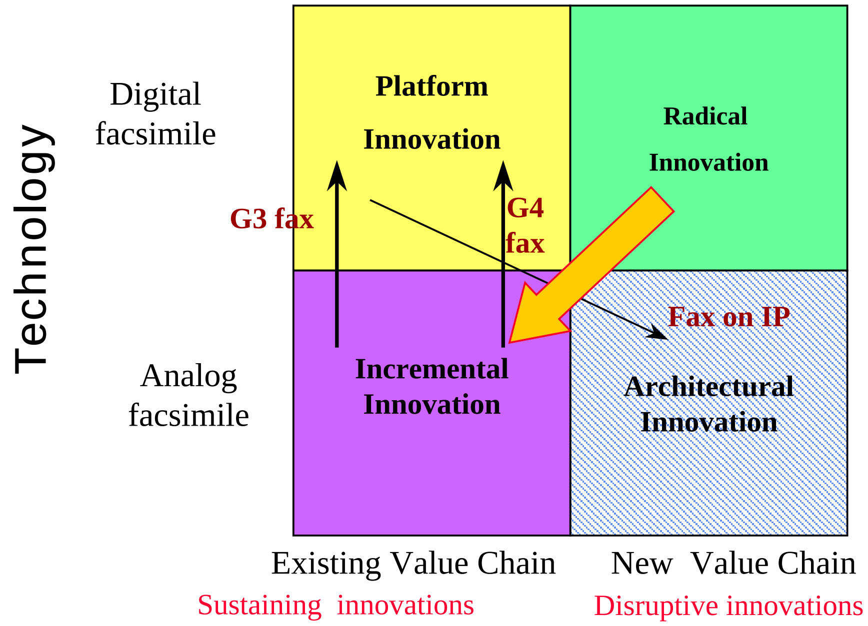
Innovation in Telecommunications Services



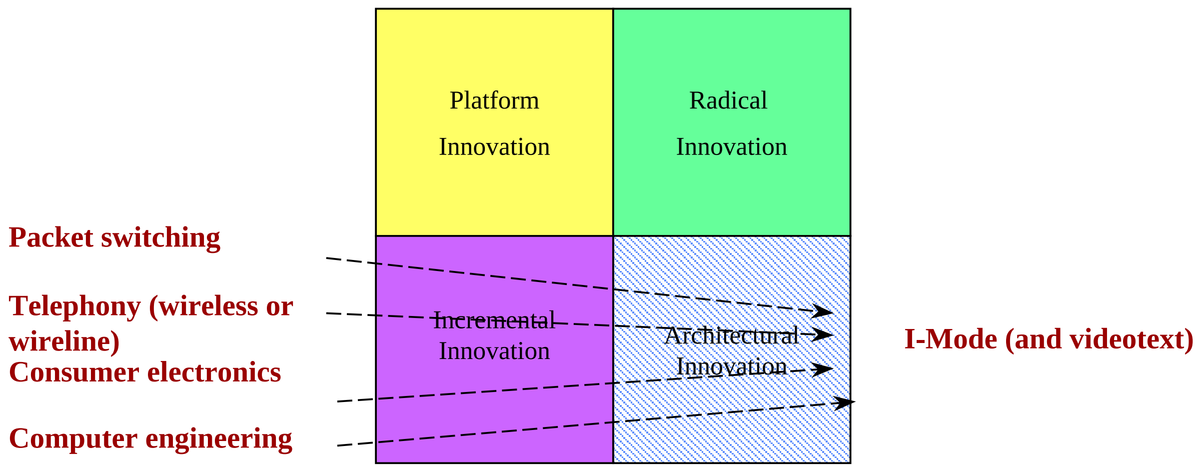
Examples

- Incremental: telephone answering machines or increasing speeds
- Architectural: reverse charging, i-mode, minitel, Bluetooth, camera phones, domotics
- Platform: X.25 -> frame relay -> ATM
- Radical: modems, packet switching, IP routing

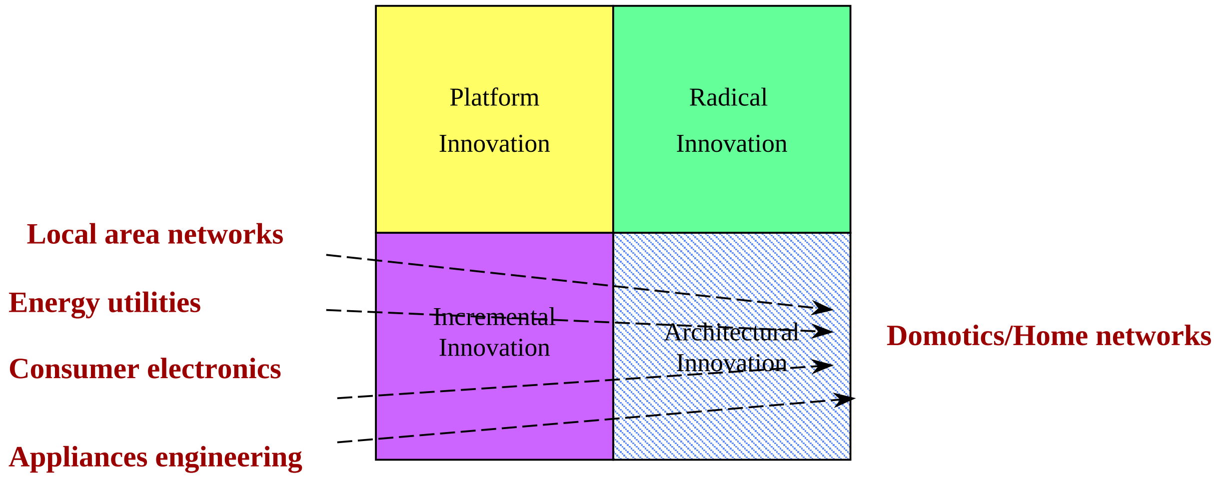
Evolution of Telecom Services - Facsimile



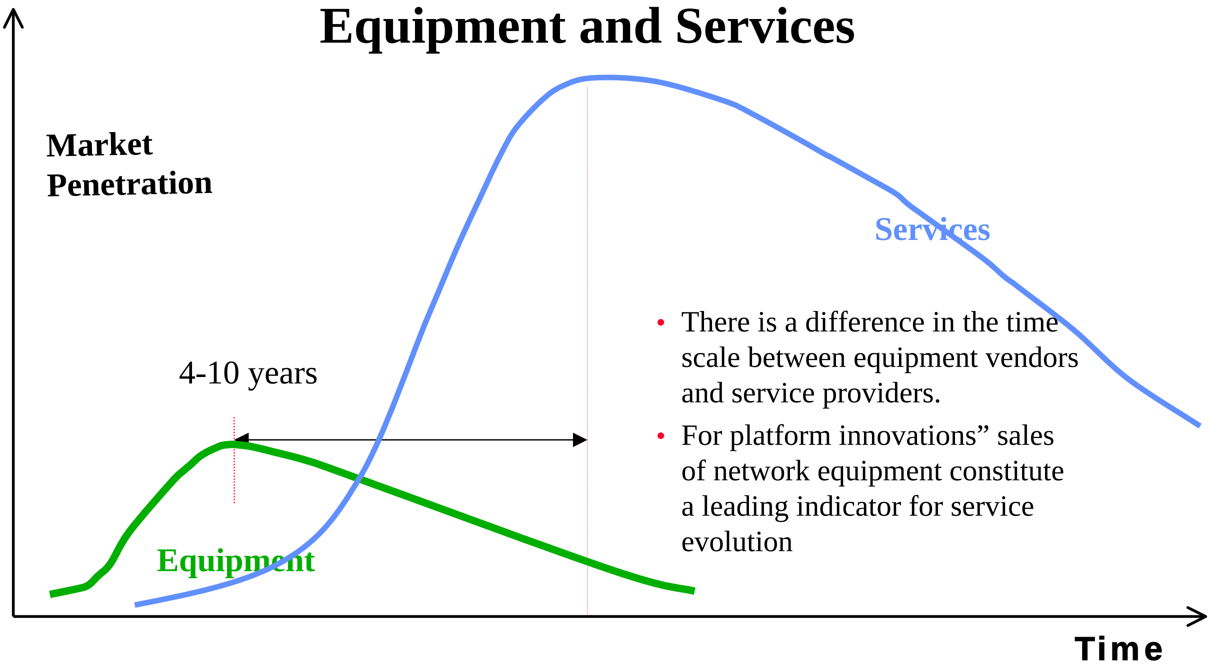
Evolution of Telecom Services - I-Mode (and videotext)



Evolution of Telecom Services - Domotics or Home networks



Platform Innovations in Telecommunications Equipment and Services



- There is a difference in the time scale between equipment vendors and service providers.
- For platform innovations" sales of network equipment constitute a leading indicator for service evolution

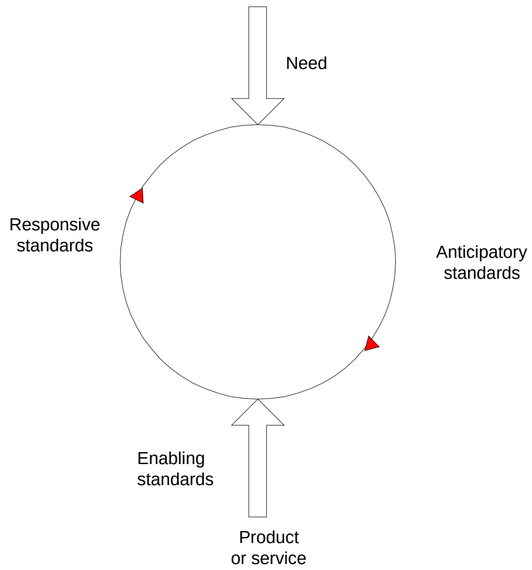
Standardization for Telecommunication Services

- Internal standards
  - increase operational efficiency
  - improve response to emergencies
- External standards
  - Reduce uncertainties concerning equipment compatibility
  - Establish framework for negotiation with other carriers and virtual operators
  - Ensure continuity of supply
  - Avoid monopoly of a single source
  - Reduce dependence on technical expertise
  - Standards for performance and quality
  - Communication of OSSs

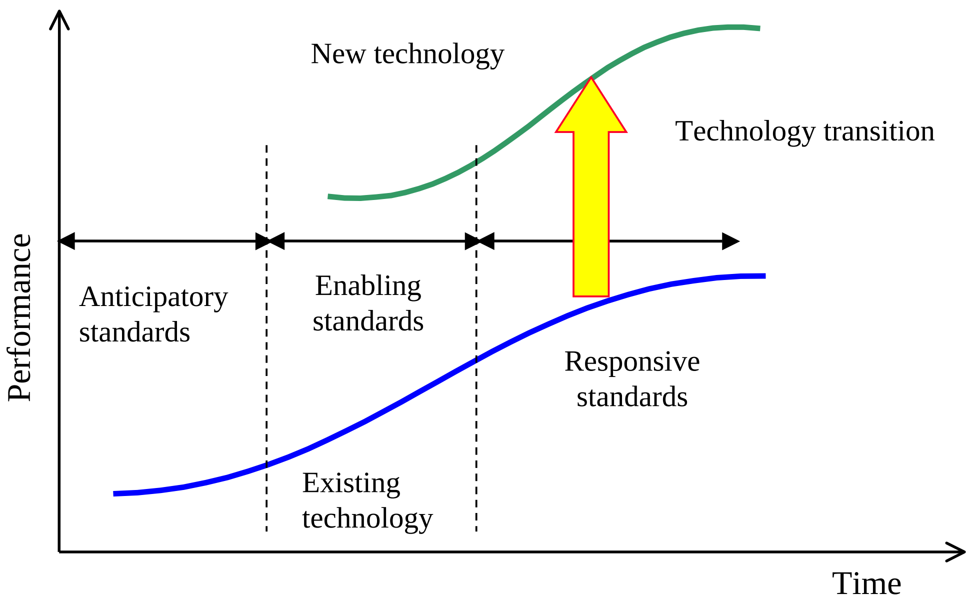
Standards Policy and Knowledge Management

- It takes 3-4 years on average (range 1 -10 years) for an external standard to be developed and successfully implemented in commercial products
- Approaches to standardization
  - Follow the dominant trend
  - Passive participation
  - Technical contribution
  - Influence market expectations
  - Start a new consortium

Marketing Aspect of Standardization



Technology View of Standardization



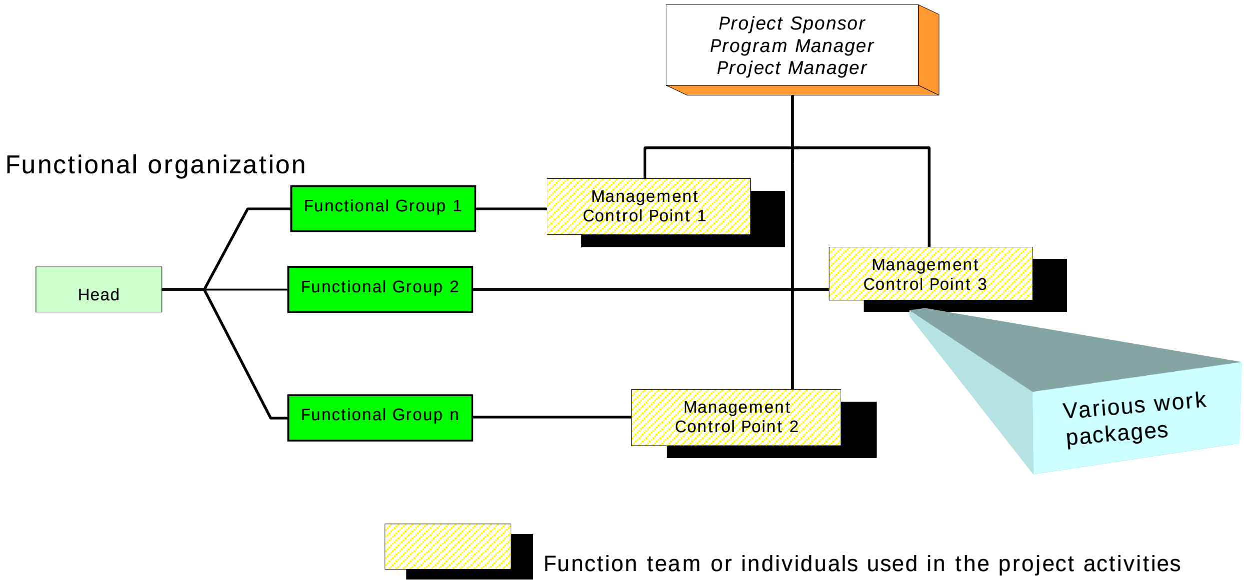
Examples

- Anticipatory standards
  - ISDN, WAP or GSM (partly), X.25, TCP/IP, UMTS, G3 and G4 facsimile, etc.
- Enabling (participatory) standards
  - GSM
- Responsive standards
  - GPRS, SMS (for service providers, but anticipatory for equipment manufacturers)
  - HDLC
- Architectural innovations tend to avoid standards (minitel, i-mode, smart cards, etc.). Exceptions: Bluetooth and WAP

Lack of Standardization

- OSSs are not standardized:
  - Custom solutions to integrate proprietary OSSs in modern networks.
  - Maintenance and update of OSSs is very expensive
  - Impedes back office integration
  - Increases the time to roll out new services
  - Services across administrative domains are managed manually: increase the cost of operation by 10-20%
  - Lack of standardization affects the ease of global networking
  - IT providers need to be convinced to open interfaces
- Many “zero provisioning” initiatives to automate provisioning
- IT providers should consider that standardization of OSS interfaces is also in their best interest.

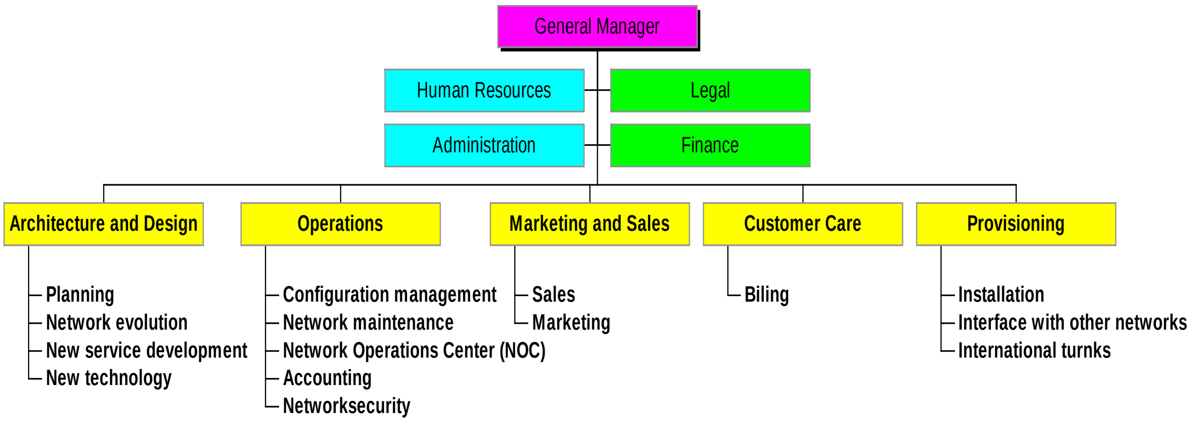
Project Management Context



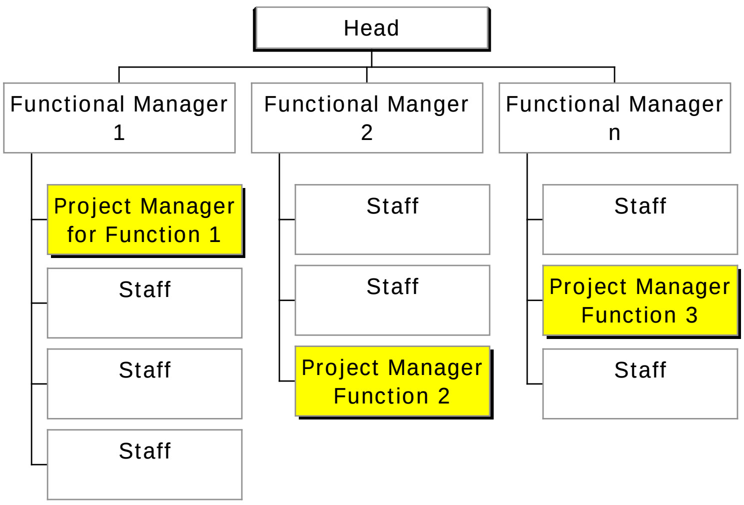
Project Team Organization

- Telecommunication service projects are actual a set of projects interlinked
- Functional organization
- Matrix organization
- Projectized organization

Functional Organization



Projects in a Functional Organization



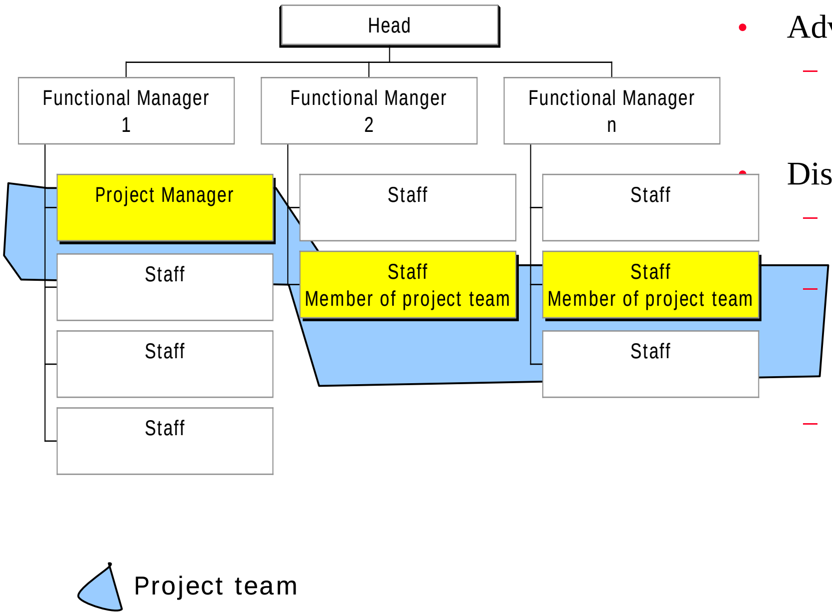
Evaluation of Functional Organizations

- Examples:
  - Acceptance testing of network elements
  - Measurement of end-to-end quality of service
  - Development of tools for bandwidth planning
- Advantages
  - Works well in a stable environment
  - Functional expertise accumulated from project to project
  - Responsibility, resources and performance evaluation are aligned
- Disadvantages
  - Limited view of the overall project except at a high hierarchical level
  - Functional responsibilities take precedence over project responsibilities
  - Multi-functional coordination is difficult

Matrix Organization

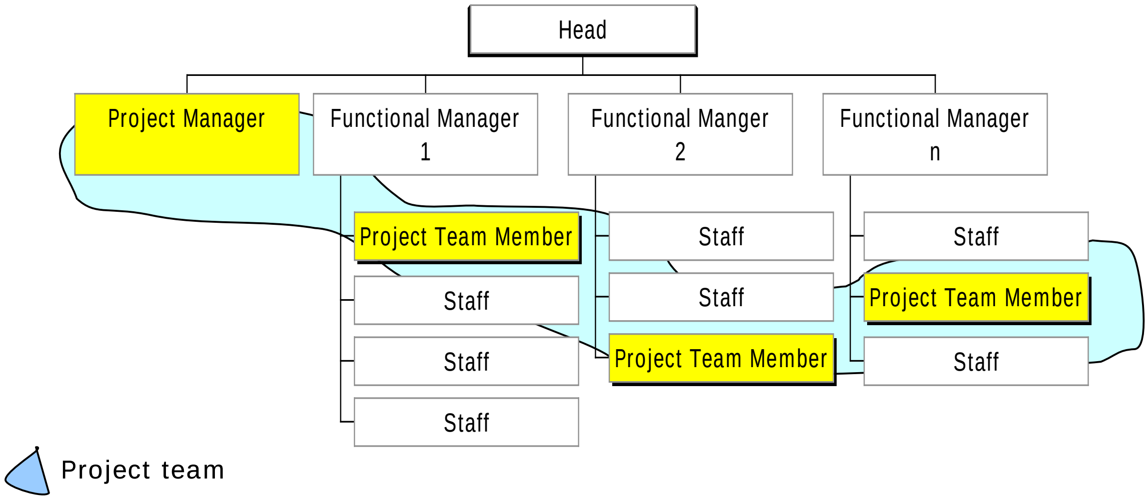
- Dual reporting structure: project manager and functional manager
  - Weak matrix: balance of power favors the functional manager
  - Strong matrix: balance of power favors the project manager, the functional manager supplies the resources
  - Balanced matrix: equal partitioning of power
- Examples:
  - Upgrading of switch software or hardware (balanced matrix: marketing and technical)
  - Management of emergencies and disaster recovery (strong matrix)
  - Establishment of network activation date (week matrix)
  - Regional project of a global telecommunication service company

Evaluation of Matrix Organizations



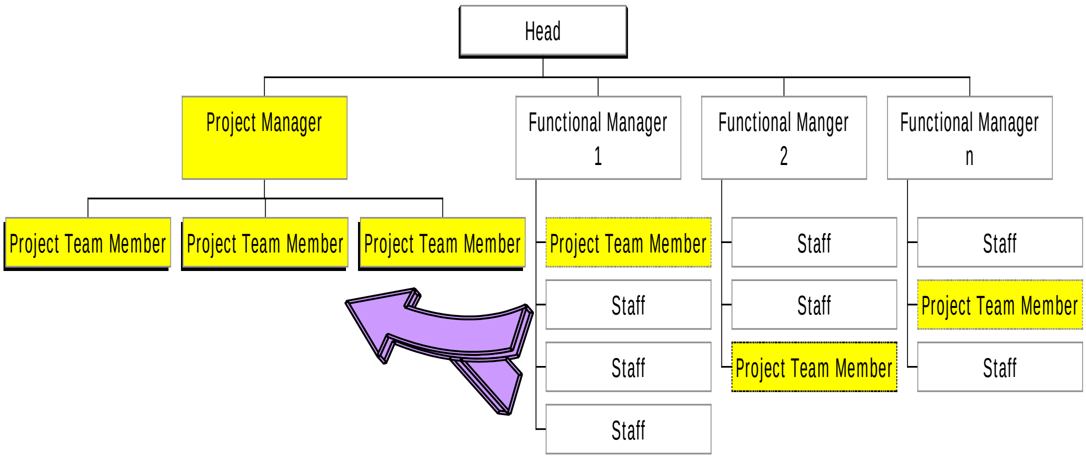
- Advantages
  - Improved communication and coordination across functions
- Disadvantages
  - Strong matrix disrupts normal routines
  - Weak matrix: the project manager has little formal control over people, budget
  - Lack of identifiable control can cause organizational chaos in case of 3-dimensional controls such as technical, marketing and geographic

Balanced Matrix Organization



Example: TAT12/TAT 13 - From different companies

Projectized Organization

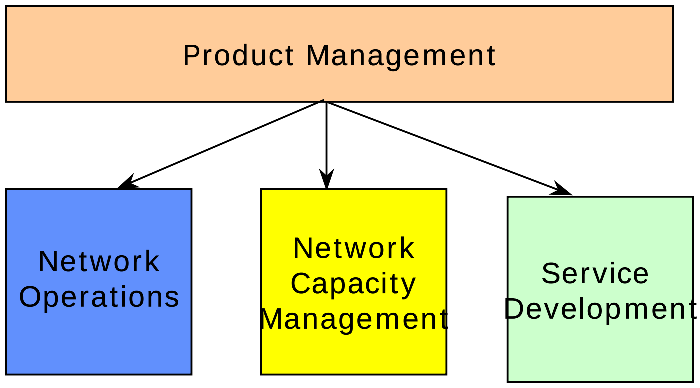


Evaluation of Projectized Organizations

- Other names: task force, project organization, tiger team, etc.
- Used when focus is needed
- Temporary Activities
  - customer project
  - response to RFP
- To avoid disturbing existing business
  - Introducing new technologies
  - Operating a foreign subsidiary

Organization and Incremental Innovation

- Stable organization
- TQM (e.g., quality) circles to improve quality and share knowledge
- Standardization to share knowledge
- R&D: increase depth and understand the limit of the technology



Organization and Innovation (cont.)

- Architectural innovation
  - Usually large team led by marketing
  - Multifunctional team arranged as a strong matrix or projectized organization
  - R&D define technical points for the marketing package
- Platform innovation
  - Strong matrix or projectized matrix
  - Project manager is a senior technical manager
  - Training needed for new skills

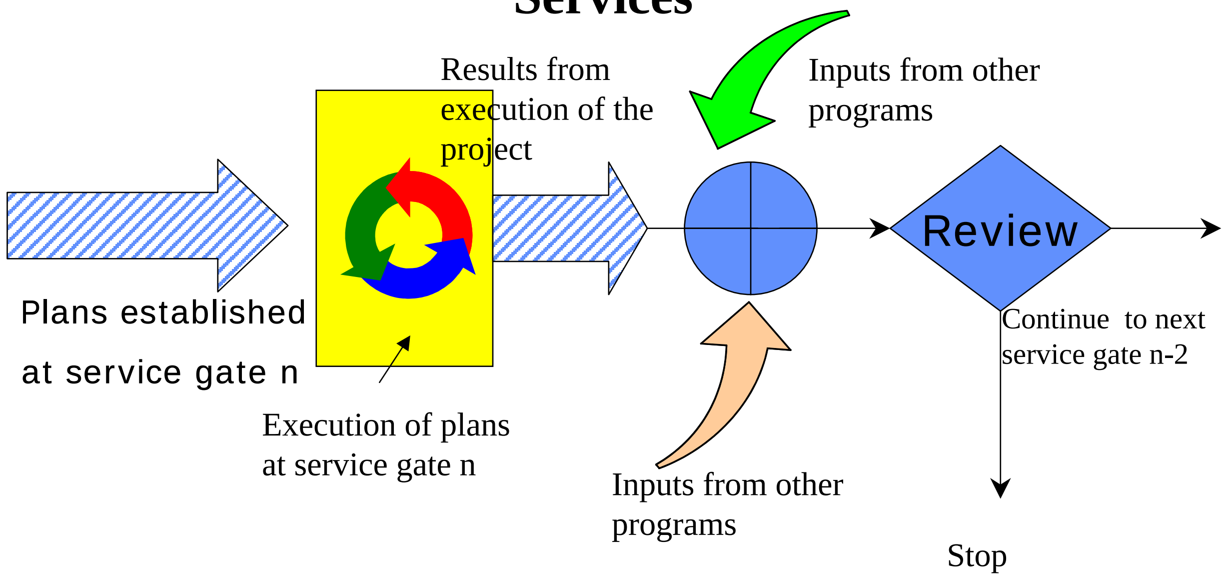
Organization and Innovation (contd.)

- Radical innovation
  - small team
  - projectized
- Transition from one mode of innovation to another may pose a significant organizational challenge due to differences in rewards measurement and resource allocations

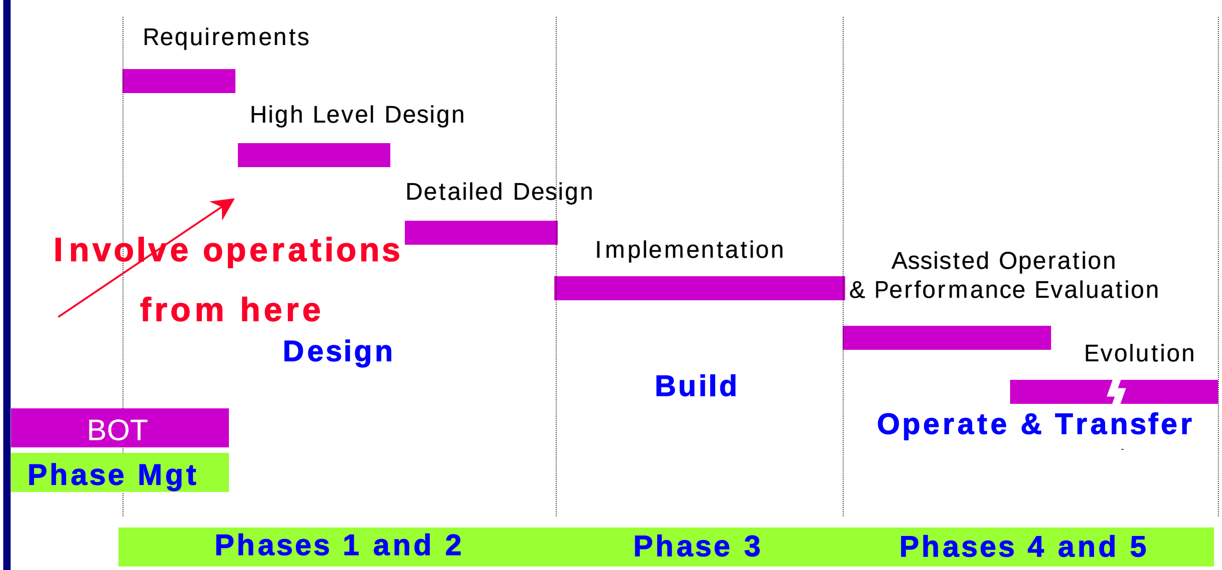
Phase Management and Portfolio Management

- Portfolio management to balance a collection of projects (or programs) to ensure the longevity of the company
- Track dependencies within and across multiple projects and programs through gate points
- Analyze the whole situation before crossing one gate point to another
- Also called the rolling wave approach

Iterative Planning for Telecommunication Services



Phase Management and the BOT Model (Outsourcing the project management)



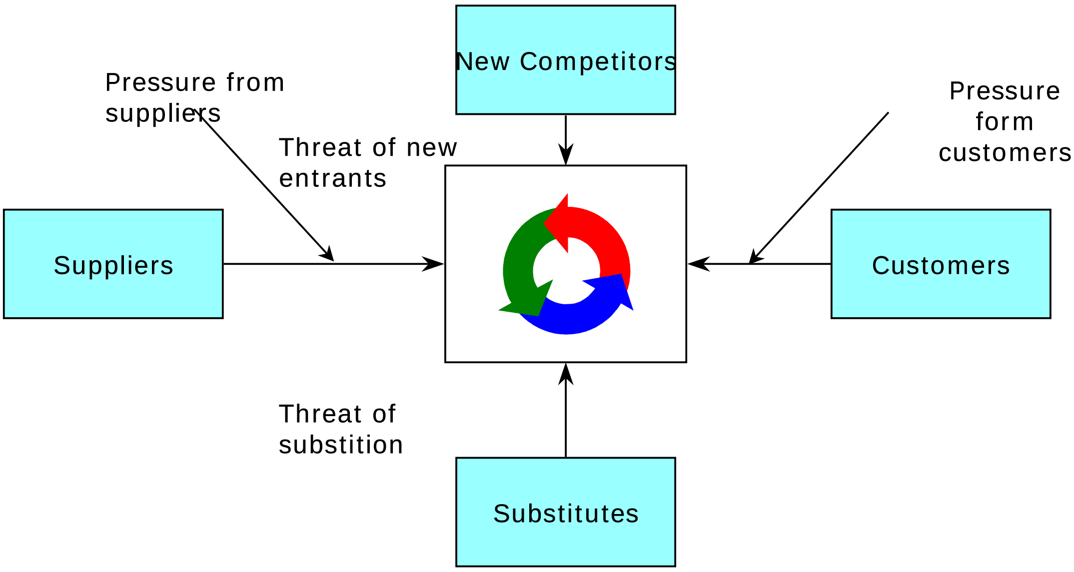
Scope Management

- Scope defined with the work breakdown structure (WBS)
- Total work is decomposed into packages
- Each package is the amount of work that a single person can perform in 2-3 weeks

Check list for Work Decomposition
(Raz and Globerson)

- Accuracy of the cost and duration estimates
- More than one person assigned to the work package (WP)
- More than one functional activity
- Internal timing of the work package
- Costing activities internal to the work package
- Dependencies between the internal activities of a WP and other WPs
- Significant interruptions within the work package
- Different precursor activities to the individual activities internal to the WP
- Any acceptance testing applicable to the deliverable before the entire work package can be done
- Any intermediate deliverables
- Specific risks to internal activities that require focused attention

Factors of Change



Reasons for Change

- Incorrect assessment of demand and revenue expectations
- Problems with the deployment
- Lack of necessary expertise
- Technological changes
- Internal changes in the organization
- Change in regulations

Changes due to Restructuring of the Industry

- Changes in the industry structure due to acquisitions or spin-offs (Salt-Lake City Winter Olympics)
  - AT&T original sponsor
  - AT&T splits into AT&T and Lucent ; Lucent spins off Avaya
  - Management of telecommunications for the Olympics must deal with 3 additional companies instead of the original one

Changes due to Industry Restructuring

- MFS Network Technologies awarded the contract for E-Z Pass installation and toll violations collection to pay for the project MCI and MFS Network Technologies merge
- WorldComm sells MFS to Able Telecom Holding Corp
- MFS becomes Adesta Communications
- After installing 320 out of the 680 toll lanes, Adesta declares bankruptcy => no further installation of additional tolls nor processing of the violators and raising money to cover the expenses

Tracking and Change Control Policy

- Change control or configuration management
- Accept only formal changes
- Streamline changes through a change control board.

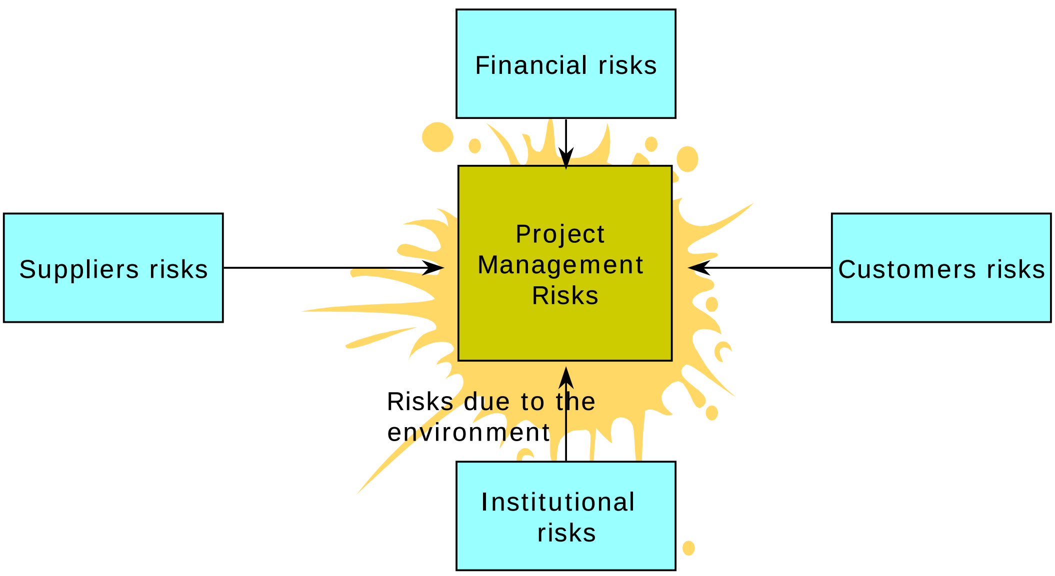
Problems of Incorrect Scope – Failure of Telecom Services Alliances

Alliance Name/Parties in the Alliance	Start Date	End Date
BT and EDS		1993
Telecom Italia and IBM		1995
BT and Portugal Telecom		1998
Telecom Italia and Cable &Wireless		1998
AT&T, BT and KDD (GIMM)	1985	1998
Unisource (KPN, Telia, Swisscom)	1991	1999
Atlas Communications (Deutsche Telekom, France Telecom)	1993	1995
Word Partners (AT&T, KDD, Singapore Telecom)	1993	1998
Concert (BT ,MCI, PT Austria, Portugal Telecom, Tele Denmark, Telefónica, Telenor)	1994	1997
Global One (Deutsche Telekom, France Telecom, Sprint)	1996	1999
Telefónica and Unisource	1996	1997
Telecom Italia and AT&T	1996	1998
AT&T and Unisource	1996	1998
Telefónica and Concert	1997	1997
Concert (AT&T and BT)	1998	2001
Vizzavi (Vodaphone and Vivendi Universal)	2000	2002

Risk Management in Telecommunications Projects

- Risk management is necessary to reduce uncertainty
- Risk management is the basis for risk avoidance or mitigation and disaster recovery
- Business continuity is part of the overall quality of telecommunications service particularly, in the case of temporary endeavors
- Disaster recovery plans ensure fast recovery and restoration of service even in the event of a natural or man-made

Sources of Risk in Telecommunication Project



Risk Management

- Identification of the source of risks
  - Recognizable risks
  - Unmanaged assumptions
- Risk evaluation
  - There is a learning curve in the case of a new service
- Risk reduction plan through preventive actions, contingency planning and disaster recovery
- Financing the residual risks

Institutional Factors

- Lack of user/top management support (appears in the form insufficient resources in terms of money and people)
- Risks that the sponsor may change its plans. These risks increase with long schedules.
- Possible hidden agenda by one or several of the stakeholders.
- Intensity of coordination required among organizations
- Not learning from past projects

Operating Conditions

- Problem for long planning stages (5 years in the case of the Olympics)
- Unanticipated changes in the regulatory environment (legislation, court decisions, etc.) particularly in international operation
- Wars, fires, riots, coups, earthquakes, wars, etc.
- Rapid expansion without adequate infrastructure, merger or acquisition, => equipment incompatibilities
- Layoffs or rapid turnover of staff and management => loss of institutional memory

Suppliers Risks

- Equipment Suppliers
  - Constant churn due to the introduction of new products and services
  - Vendor quality (i.e., no implementation of best current practices)
  - No clear committed owner of the project on the supplier's side
  - Inadequate supplier support (quality, timeliness, features, etc.)
- Interconnection Suppliers (interfaces, lead time, availability, support, etc.)

Financial Risks

- Inflation, stock market, currency fluctuations, etc.
- Unanticipated technical difficulties, or labor shortages, frequency of reworks, new infrastructure needs, etc.
- Long schedules increase financial risks
- Inadequate configuration control
- Projects that are out of control (in terms of schedule or cost) are most likely to be canceled

Environmental Risks

- Unusual conditions (fire, floods and earthquakes, hurricane/tornadoes, blizzards, snow storms, heat waves, hazardous materials contamination)
- Sunspot cycles
- Rodents or fish chewing an underground or undersea cable

Other Risks

- Technology risks
  - expertise with the technology
  - presence or lack of standards (m-Commerce)
  - maturity of the technology (3 G)
  - rapid development may make a project obsolete (DSL ?)
  - Network "meltdowns"
- Resource Risks
  - training of the personnel (may rely on temporary workers)
  - high turnover of trained human resources
  - culture sensitivities in international projects

Delays in Telecommunication Projects

- Access
- Weather conditions, such as in the case of laying out cables outdoors or in conduits (rain, snow or heat waves delay the work)
- Work rules on the number of work hours per day) holidays, etc. Consider the case of laying fiber optic cables next to train track.
- Logistics (shipping, customs procedures, installation), which are important in the case of international deployment
- Stakeholders agreement

Crashing in Telecommunication Services

- Re-use a previously tested equipment and software releases from already certified vendors to shorten the time for installation
- Use manual procedures (for provisioning and billing) until the OSS is able to handle the new service automatically
- Redefine the scope of the project to postpone activities causing delays, for example by offering only those features that are known to work
- Plan to start with the sites with the highest probability of success early in the project. This has the advantage of uncovering problems that might have been missed and resolve them with less pressure and of showing immediate progress to gain momentum. The experience gained and the slack can be used to address problematic installations.

Innovation and Cost Management

- Cost and the time estimates for a project are defined and refined in the concept, feasibility and definition sub-phases.
- Rough Order of Magnitude Estimates (ROMA) with decreasing margin of errors
- Scope of work defined with the WBS, a bottom-up exercise

Sub-Phase	Lower Error Margin	Higher Error Margin
Concept	-25%	75%
Feasibility	-10%	25%
Definition	-5%	10% (0% for time)

Cost and Innovation

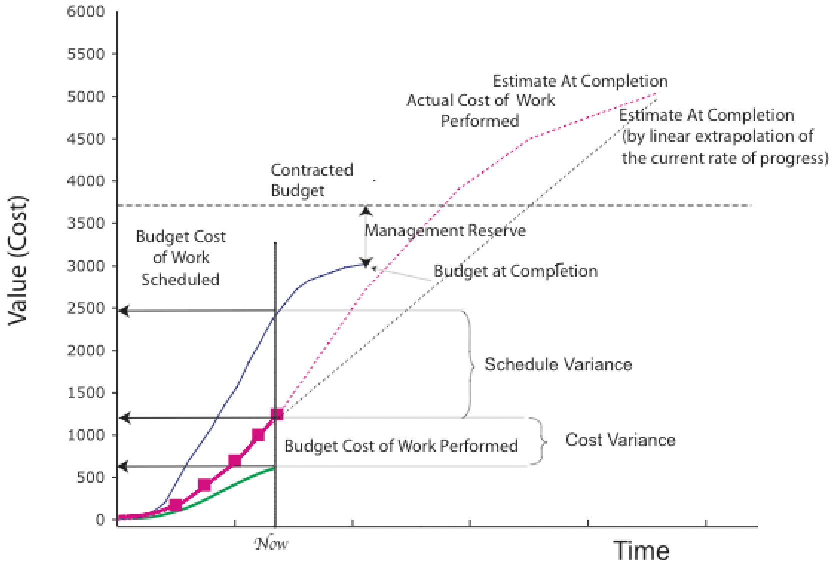
Type of Innovation	Major Cost Component
Radical	Development, engineering, testing, marketing training
Platform	Development and engineering and testing
Incremental and process	Systems for automation
Architecture	Marketing

- For non incremental innovation, the planners have a limited view of the total effort needed in critical activities such as system testing, integration with existing systems and operations and business processes.

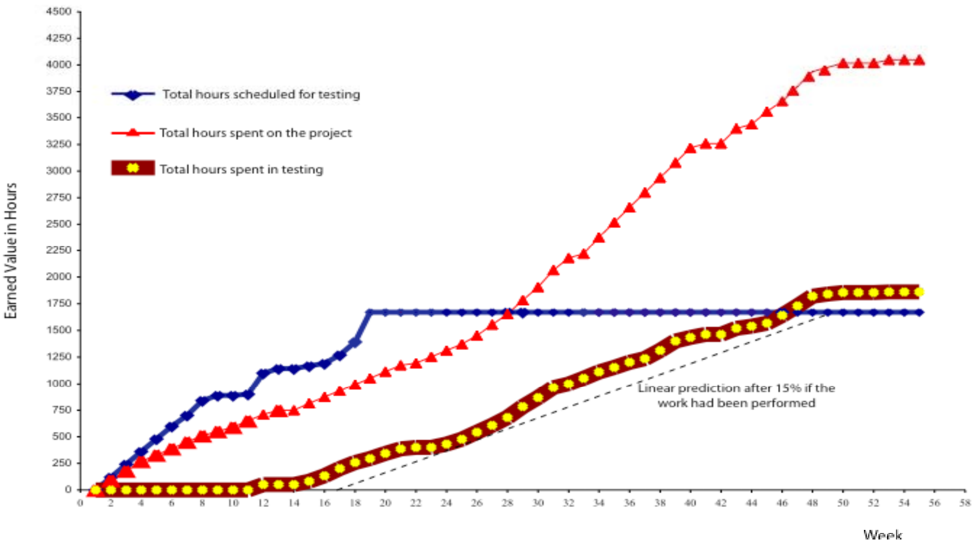
Management of Time and Cost

- Earned Value analysis
  - Cost overrun compares the budgeted value of the work accomplished with the actual spending on the work done
  - Schedule variance compares the budgeted value of the work that ***should*** have been done with the actual spending to the work done
- ANSI/EIA-748-1998
- References
  - http://www.suu.edu/faculty/christensend/ev-bib.html
  - http://www.acq.osd.mil/pm
    http://www.goldpractices.com/practices/tev/index.html.

Measures of Earned Value



Tracking of Testing Using the Earned Value Methodology



Quality Assessment of The Project

- Overall project cycle time
- Cut-overs per week
- Defects (missed cut-overs)
- Quality of installation (number of reinstalls or relocates, number and type of complaints over time, etc.)
- Satisfaction of team members with the project management team

Quality Assessment of the Telecommunications Service

- Average speed to answer a customer inquiry
- Time to restore trouble
- Mean time to repair
- Network availability (defects per minute)
- Service availability
- Billing accuracy, etc
- Quality of service is more than the networking technology

Effects of Outages

- Data networks

Type of Business	Estimated loss in U.S. K$ per minute
Brokerage	200
Manufacturing	50 -100
Point-of-Sale	20-100

- Voice networks
  – A major outage (a service failure that lasts ≥ 30 min affects more than 1 000 subscribers

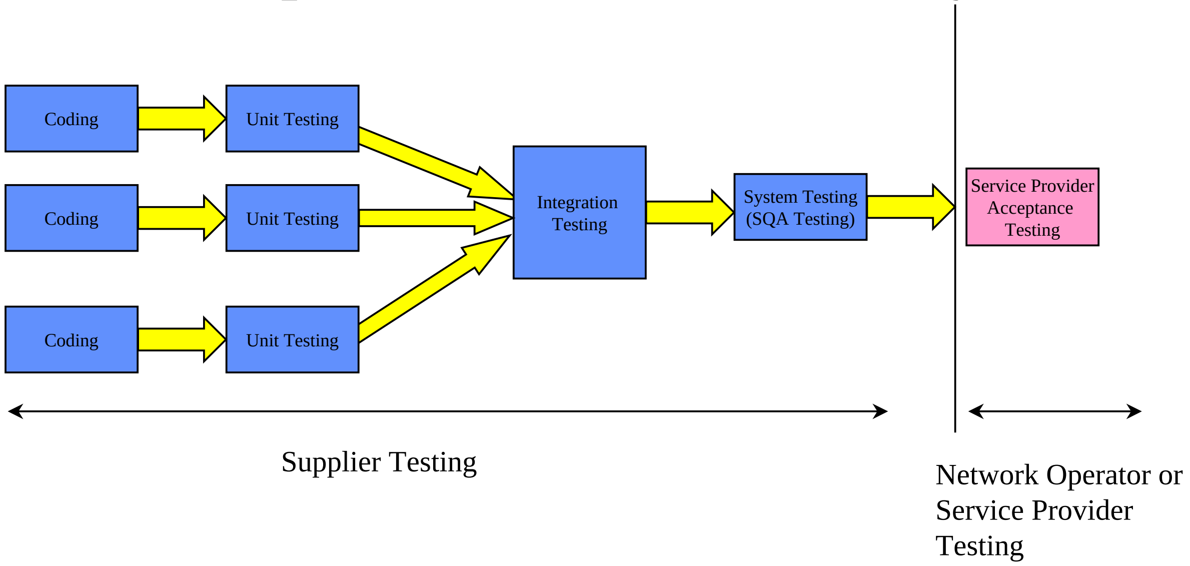
Cost of Quality

- Prevention cost P: cost associated with working around problems that could not be fixed in time for service deployment
- Appraisal cost A: cost of inspections, testing, etc.
- Failure cost F
- Total cost of quality = P + A + F < cost of quality as defined by the project sponsor
- Appraisal cost should be < P + F

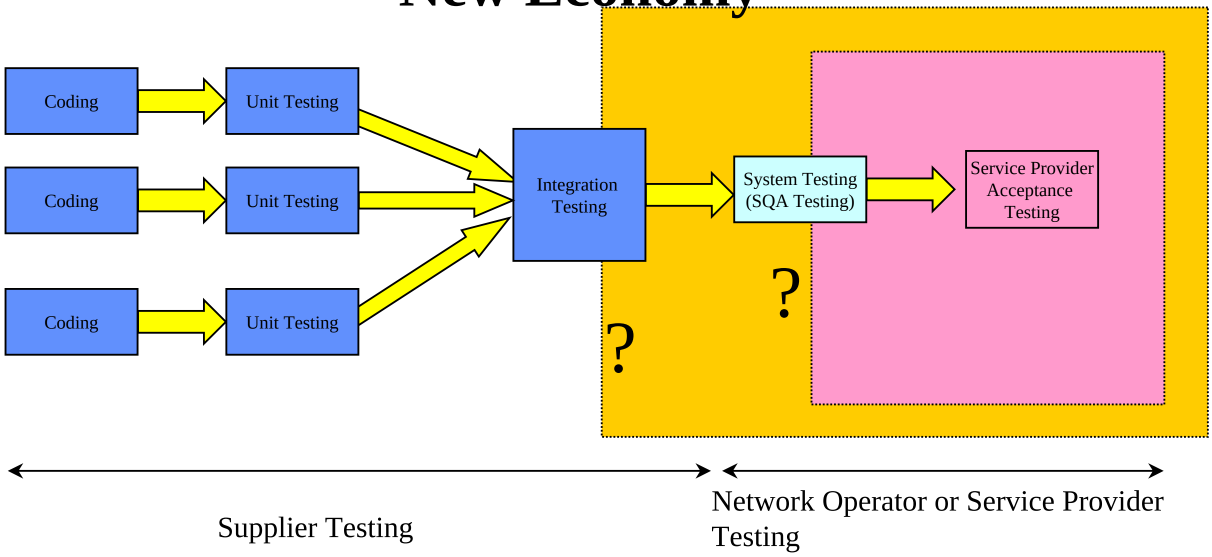
Definition of Defects Severity

- Telcordia GR-929-CORE: Public networks
  - 1 Critical
  - 2 Major
  - 3 Minor
- IEEE: Enterprise networks
  - 1 Urgent
  - 2 High
  - 3 Medium
  - 4 Low
- Severity 1 for public networks corresponds to severity 1 and 2 for enterprise networks
- Severity 2 for public networks corresponds to severity 3 for enterprise networks

Traditional Telecommunications Software Development and Maintenance Cycle



Telecommunications Software Development and Maintenance Cycle in the "New Economy"



Constraints of the New Environment

- Network elements for traditional data networks are less reliable than those for public voice networks
  - They were designed for corporate networks
- Market pressure to shorten development time ⇒ push products early to field deployment
- Inputs to the deployment decision:
  - Delay ⇒ Opportunity cost + cost of additional testing
  - Deploy ⇒ payout from service impact on customer's traffic

Problems in Achieving Service Quality

- There are many service features to be tested (compared to just point-to-point voice transmission in traditional telephony)
- For a new technology ⇒ No known operational profile ⇒ Test plans may be incomplete
- Software architecture is unknown
  - Not all features are documented
  - Black-Box testing vs. White Box testing
  - Vendor support is critical
- Lab testing is not sufficient ⇒ real life testing in the form of a controlled introduction

Test Cycles

- Lab Testing
  - Phase 1 - Complete functional test coverage of existing and new features.
  - Phase 2 - Verification of defect fixes from Phase 1, production and additional tests for stress testing, large scale configurations, tests with invalid and inopportune inputs.
  - Phases 3 through N - Maintenance releases
- Field Testing
  - Controlled introduction
  - General release

Questions

- When is a network element/software release ready to be deployed for a given service?
- What is the expected reliability of the network element/software release?
- Is the testing profile consistent with the traffic pattern in the field?

Previous and Related Work

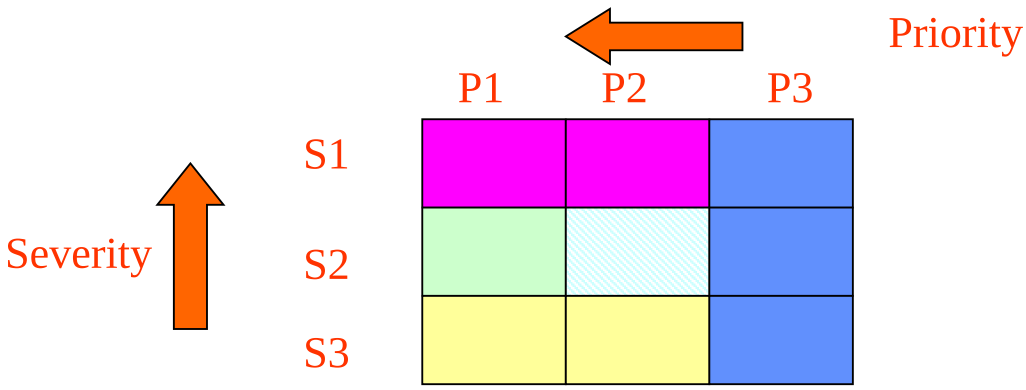
- Jelinski-Moranda (1972) (Product model)
- Musa, Iannino, Okumoto. (1987) (Process model)
- Applications in Telecommunication Systems
  - Bellcore - Dolinsky and Glickman (1994)
  - France Telecom Derriennic and Le Gall (1995)
  - Lucent: Zhang and Pham (2002)

Framework for Answers

- Focus on features of interest to the service as distinct from the product
- Focus on number of faults remaining with respect to rate of defect discovery (failure intensity)
- Base deployment on comparison of the cost of further testing to the penalty of a field problem
- Verify correctness of testing through a controlled introduction in the field (after the defect discovery rates have been reduced to an acceptable level)

Classification of Defects

- Reliability (=> severity of the defects)
- Release Plan (=> priority) based on TSD
- For each network element and feature



Statistical Evaluation of the Results

- Use the time series of the observed defects over time
- Estimate reliability and if it increases with time
- Use software reliability models (Musa's basic model and Jelinski-Moranda model)
- Define a new metric "deployability" to track the reliability growth
- Perform a Bayesian analysis on the number of remaining defects before making a decision
- CASRE tool available from the Open Channel Foundation www.openchannelfoundation.org

Musa Basic Model

- Defect discovery times $\{t_1, t_2 \cdots t_m\}$
- Poisson process :

  $f(t_1) = \lambda e^{-\lambda t_i}$ and $f[t_i - t_{(i-1)}] = \lambda e^{-\lambda[(t_i - t_{(i-1)}]}$

  for i = 2, ..., m, where f(x) is the probability distribution of X
- Considers the process of software development $\mu(t)$
  - uses of the expected number of failures
  - more suitable to an equipment development organization

Musa Basic Model

- Expected number of defects discovered at time t

$$\mu(t) = \nu_0 \left[1 - e^{-(\frac{\lambda_0}{\nu_0} t)} \right]$$

- ν_0 = the expected total number of failures that would occur at infinite time
- $\lambda(t) =$ failure intensity $\frac{\partial \mu(t)}{\partial t}$ with $\lambda_0(t)$ the initial failure intensity

$$\lambda(t) = \lambda_0 e^{-\frac{\lambda_0}{\nu_0} t}$$

Some Relations for the Basic Model

- Failure intensity (also called hazard rate) w.r.t. time

$$\lambda(t) = \lambda_0 e^{-\frac{\lambda_0}{\nu_0} t}$$

- Failure intensity with defect number

$$\lambda(\mu) = \lambda_0 \left[1 - \frac{\mu(t)}{\nu_0} \right]$$

Product Model (Jelinksi-Moranda)

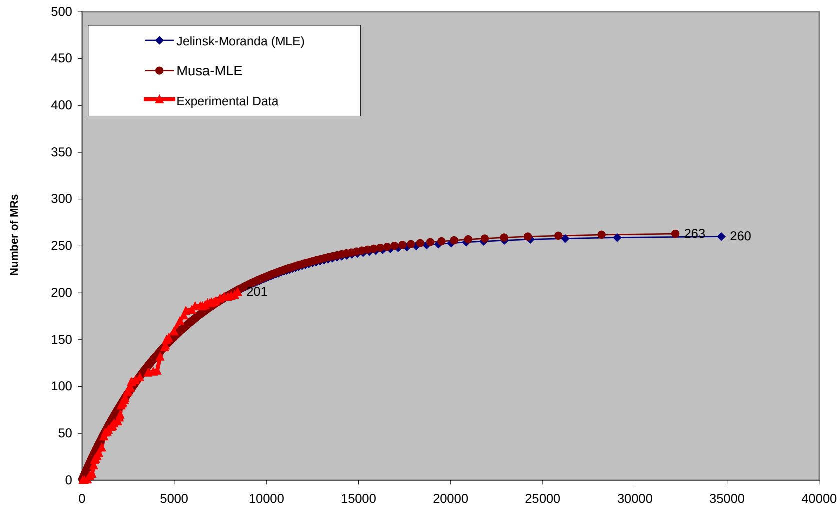
- The number of defects N is finite
- Inter-discovery time exponentially distributed with a mean of B, i.e., that the probability density of the inter-discovery time is $B e^{-Bt}$
- Defect discovery times are $\frac{1}{NB}, \ldots, \frac{1}{NB} + \frac{1}{(N-1)B}$
- At time t, the expected number of defects discovered is

$$\frac{1}{B}\sum_{j=0}^{m-1}\frac{1}{(N-j)} \le t < \frac{1}{B}\sum_{j=0}^{m}\frac{1}{(N-j)} \quad \text{for } m = 0, 1, \cdots, N$$

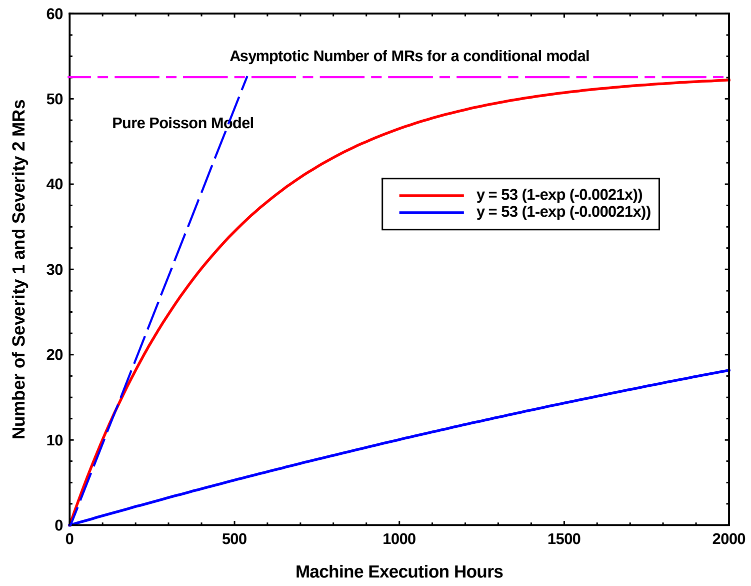
- Failure intensity is $z(t) = \lambda(t) = B\left[A - (i-1)\right]$

$$E(N) = \nu_0 \text{ and } E(B) = \frac{\lambda_0}{\nu_0}$$

At Convergence - Both Models Behave Alike



Principle of Deployability Analysis



Deployability Analysis (1)

- $\gamma_m = \dfrac{L_i(t_1,\cdots,t_m)}{L_0(t_1,\cdots,t_m)}, i = 1,2$ 1 for Musa Basic, 2 for Product
-
- Likelihood for Poisson $\ln L_0(t_1,\cdots,t_m) = m \ln(\lambda) - \lambda t$
- Likelihood for Musa Basic Model

$$\ln L_1(t_1,\cdots,t_m) = \sum_{i=1}^{m} \ln \lambda(t_i) - \mu(t)$$

- Likelihood for Product Model (Jelinski-Moranda)

$$\ln L_2(t_1,\cdots,t_m) = n(t)\ln(B) + \sum_{j=0}^{n(t)-1} \ln(N - j) - B \sum_{i=1}^{n(t)} t_i - [N - n(t)]\,Bt$$

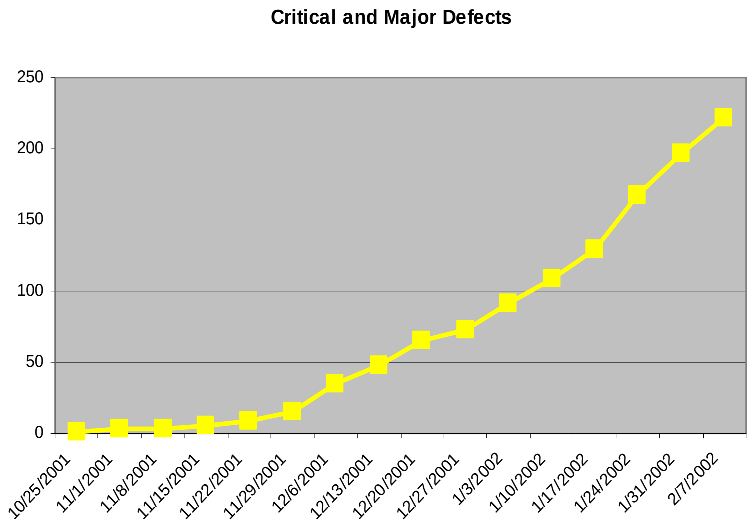
Deployability Analysis (2)

- Compare fitting the defect find rate with a Pure Poisson Model and the model for software reliability
- Rule for significant deployability growth: if the model is 20 times more likely than the Pure Poisson Model in terms of maximum likelihood function.
- Test stopping rule is a function of the expected time to find the next defect and the cost of test as well as the cost of a field defect

1/ Expected time to find the next defect = Discovery Rate ≤

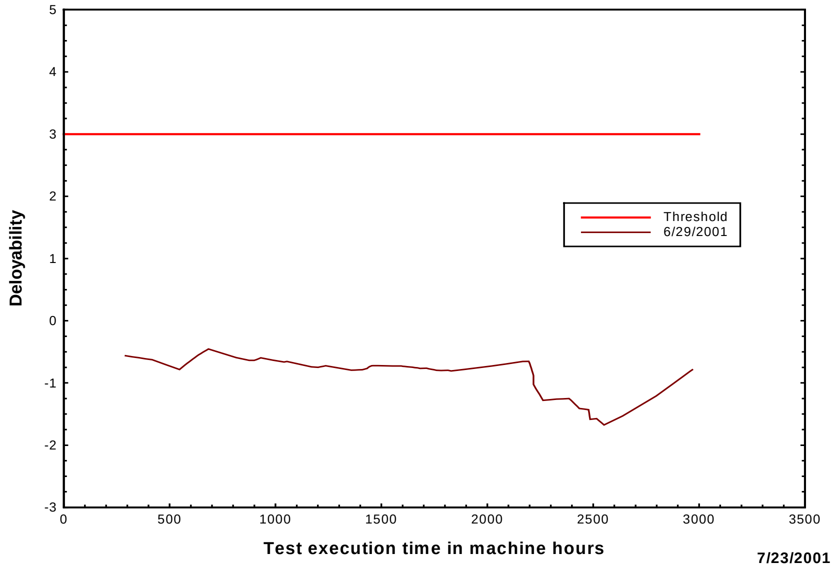
$$\frac{\text{Cost of System Test per unit of time}}{\text{Penalty of finding an defect in the field}}$$

Example 1 - Equipment Screening



- Data show that the equipment is still in the "linear phase"
- Not ready for testing by the network or service provider

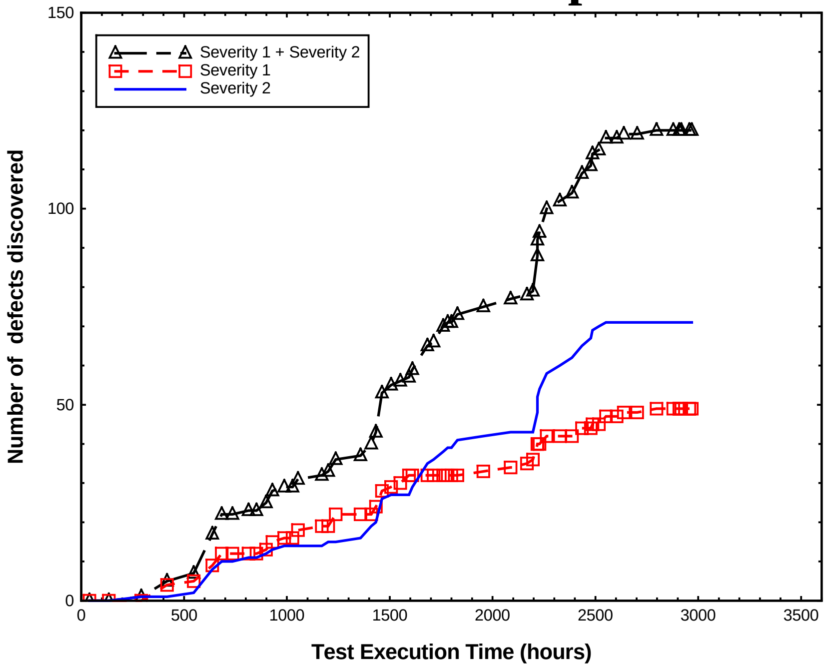
Example 2 - Product not Deployable



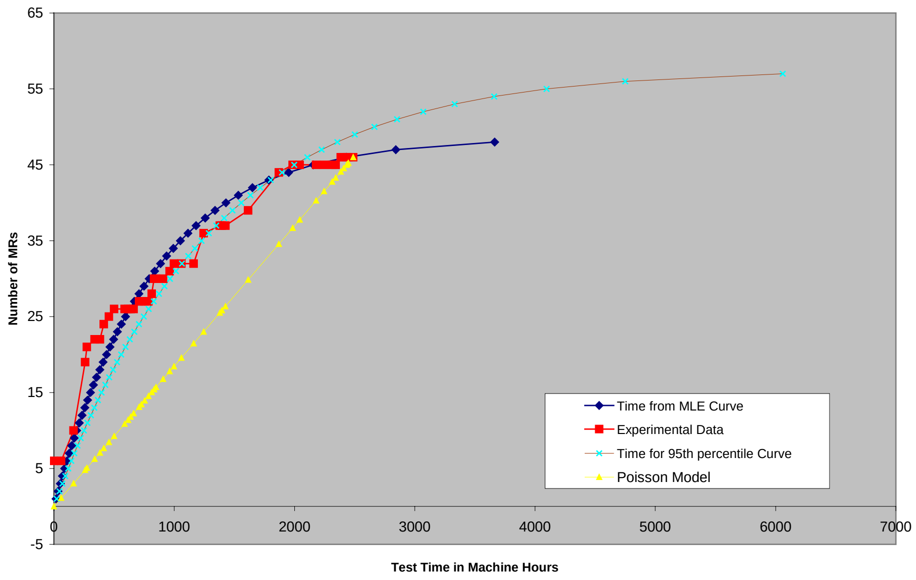
This is a measure of whether the curve has bent or is still in the linear region

Deployability growth is detected when the data are 10-20 more likely to be explained with the conditional model than with the Poisson model.

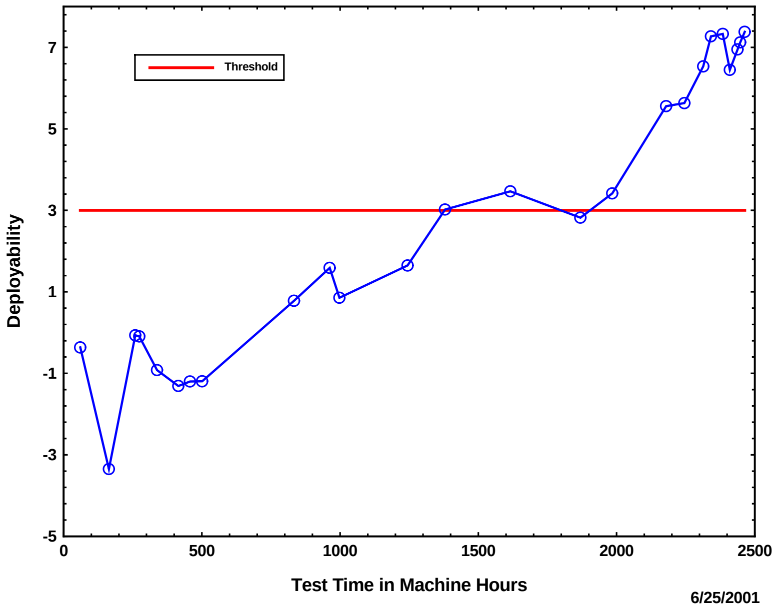
Time Series of Defect Discovery for Network Element of Example 2



Example 3 - Analysis for a Single Feature



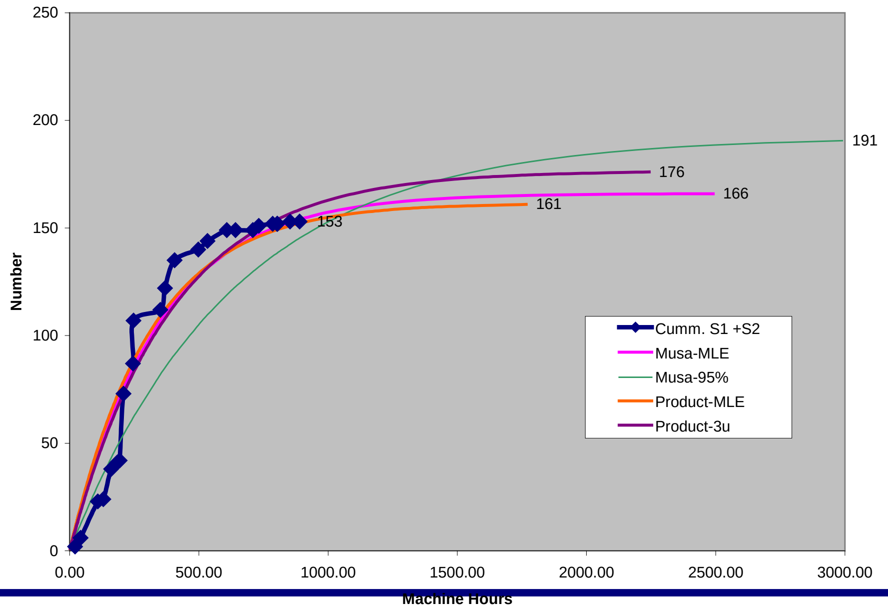
Example 3 - Deployability of a Feature



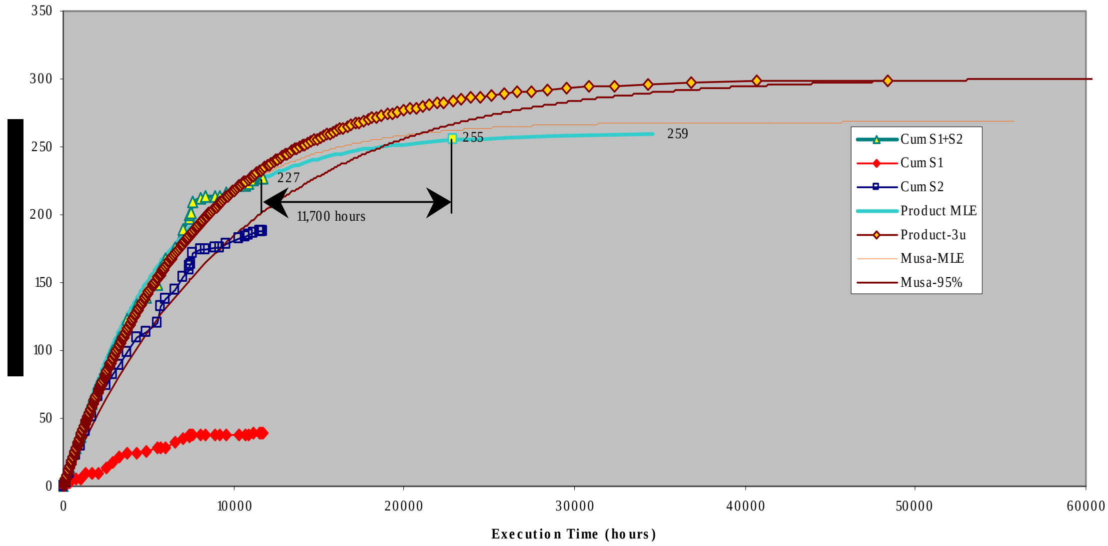
This is a measure of whether the curve has bent or is still in the linear region

Deployability growth is detected when the data are 10-20 more likely to be explained with the conditional model than with the Poisson model.

Example 4 - The curve has bended

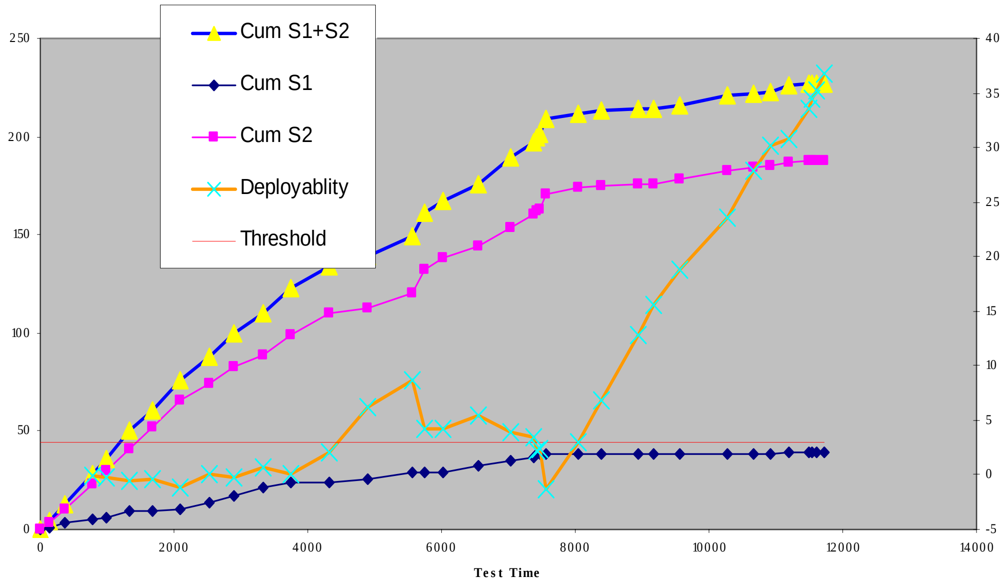


Example 5 - Estimated Remaining Testing Time with Vendor Provided Data



- Assuming that the network provider will test for more than 12,000 hours

Evolution of Deployability



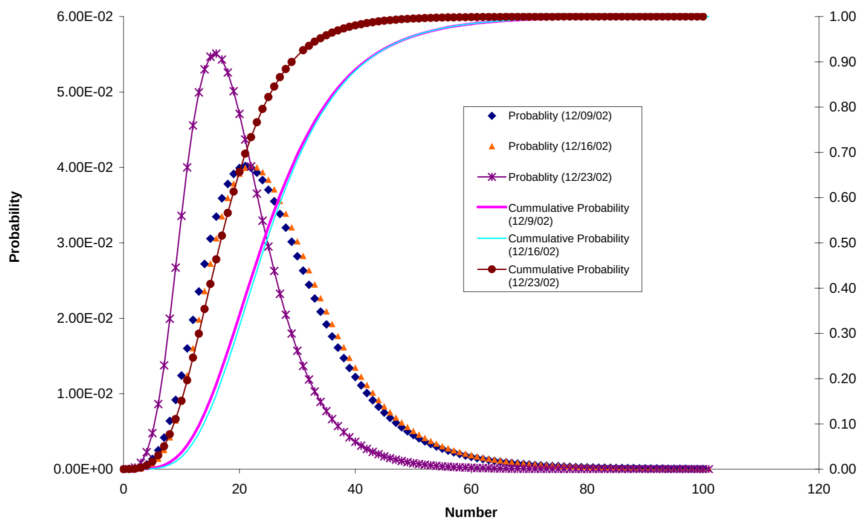
Baye's Analysis for Remaining Defects

Probability of remaining defects given the observed data

$$\frac{\int_{B_{min}}^{B_{max}} L(A,B)\, dB}{\sum_{\forall A} \int_{B_{min}}^{B_{max}} L(A,B)\, dB}$$

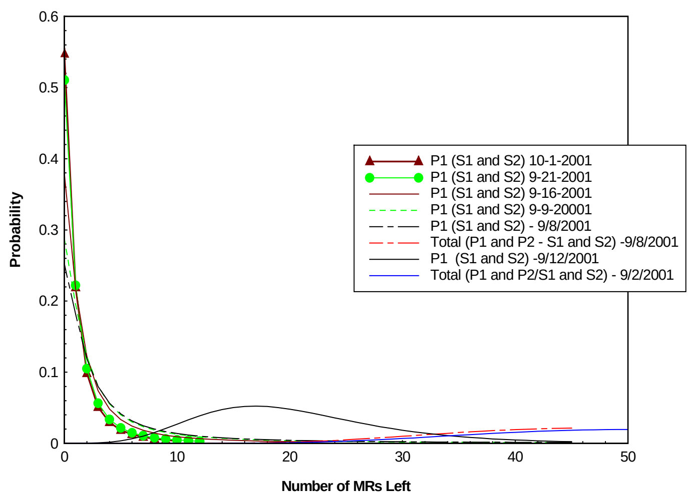
A are the consecutive positive integers 1,2, ...

Probability of Remaining MRs



- The expected penalty of the deployment can be estimated
- Deming's point 11 [1986]: ***there is no point in defining numerical standards and goals to improve the situation before understanding the root cause of the special and common cause variations***

Analysis of Remaining Defects

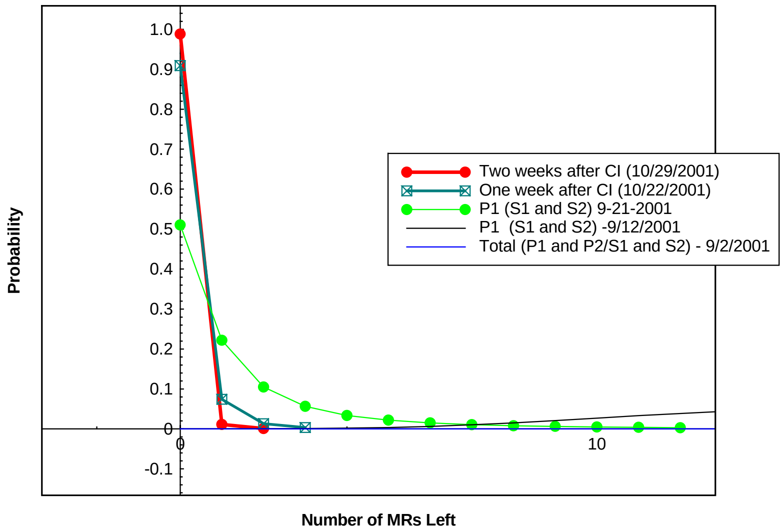


Remaining MRs	Probability
0	0.47680
1	0.22397
2	0.11112
3	0.06167
4	0.03764
5	0.02476
6	0.01726
7	0.01258
8	0.00949
9	0.00736
10	0.00581
11	0.00465
12	0.00376
13	0.00305

Most probable number is 0

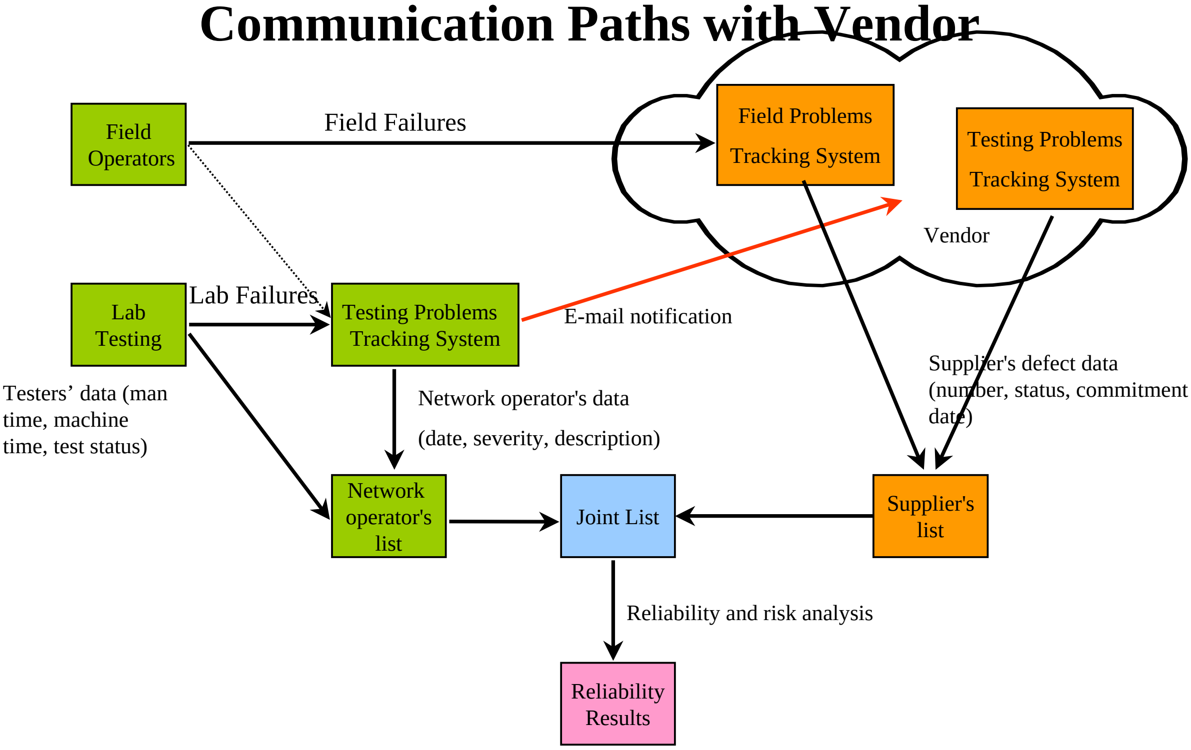
Expected value is 1.4

Remaining Failures (Detailed View)



Ready for a controlled introduction

Communication Paths with Vendor



Vendor Management

- Vendor management is not procurement management
- Deming's fourth point "*End the practice of awarding business on the basis of price tag. Instead, depend on meaningful measures of quality along with price. Move toward a single supplier for any one time, on a long-term relationship of loyalty and trust*" is very appropriate in vendor management
- Acquisition process described in ISO/IEC-11207

Procurement Management vs. Vendor Management

Characteristics	Procurement Management	Vendor Management
Purpose	Minimize transaction cost	Maximize knowledge creation and retention
Nature	Impersonal and at arm's length	Relation-specific
Main focus	Business processes, legal, SLA, penalties metrics	Business, technical, marketing, legal, strategic positioning
Dependence on the technology life-cycle	No	Yes
Areas of application	All types of innovation	Supplemental for radical, architectural and platform innovation
Performance metrics	Delivery intervals and order defects rate Invoicing accuracy	Delivery intervals and order defects rate Invoicing accuracy Innovation to improve the service offer Response to new feature requests Readiness to collaboration and information sharing

Type of Vendors

- Technology vendors (hardware, software)
- Connectivity vendors
- Service Vendors
- Consultants

Type of Agreements among Network Operators

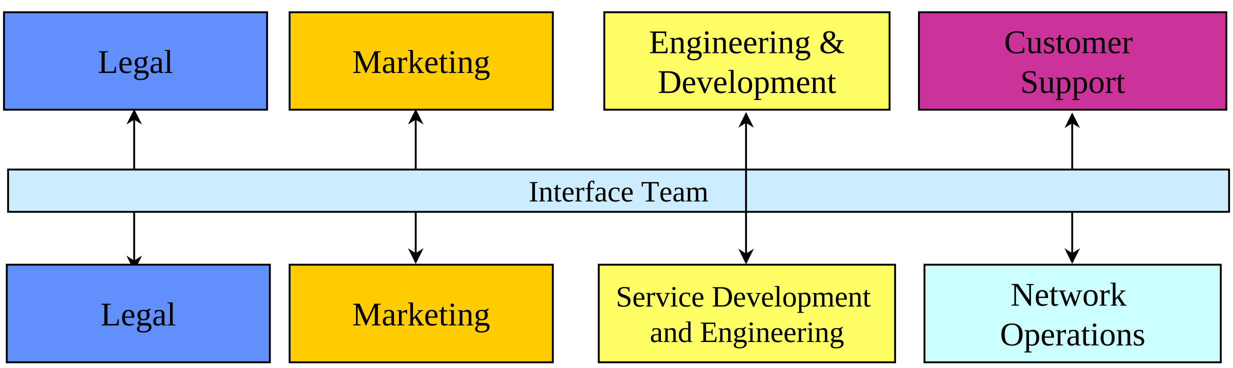
- Interconnection agreement
- Telehousing agreement
- Full service agreement (participation in the whole operation from pre-sales to turnup)
- Forced agreement (unwilling supplier) due to deregulation

Evaluation of Technology Vendors

- Metrics to evaluate the quality of telecommunication services are defined in TL 9000 from the QuEST forum (www.questforum.org)
- Vendor selection:
  - Technical reasons
  - Non-technical reasons
  - Political reasons: not conducive to long-term quality
- Technology audits may assist in vendor assessment

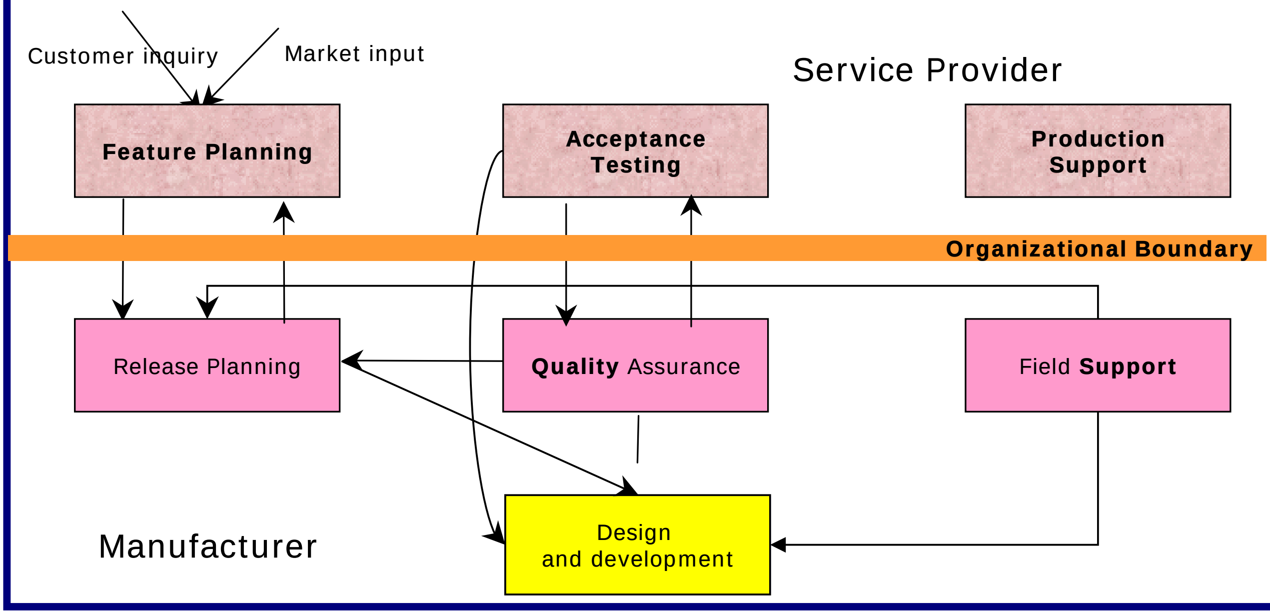
Interface with Technology Suppliers for Emerging Services

Technology Supplier



Network Operator

Sharing of Knowledge for Emerging Services



Virtual Organizations In Manufacturing and Telecommunication Services

Feature	Manufacturing	Telecommunication Services
Purpose	Lower cost s by reduced inventory and faster response to orders	Knowledge generation
Organization	Non hierarchical	Hierarchical and functional
Inputs	Customer order	Field problems or new feature requests
Existing hierarchies	Bypassed	Maintained

Risk Factors in Vendor Management

- Technology Vendor
  - Type of vendor: start-up or established
  - Type of innovation
  - Standardization
  - Congruence of the vendor’s plans with the service provider’s plan
  - Knowledge management and intellectual property (in case of knowledge sharing)
- Connectivity Vendor: meeting the intervals and quality required