Network Strategy Studies

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Every network operator needs to have a network strategy covering the complete network portfolio. The strategy must also be operational, meaning to be related to decisions and actions in near-time. One main goal for having a strategy is to be prepared for chances that can be revealed with time. That is, the strategy is likely to assist in detecting business opportunities.

A number of methods can be applied when elaborating the strategy, including scenarios, cost/benefit calculations and risk assessment – these aspects are briefly presented in this article.

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1 Introduction

In today's world, change and uncertainty seem to be constants. On the one hand this is nice, as improvements are captured in the evolution process. On the other hand, the ongoing dynamics is hard to capture in network planning with a longer time horizon. In fact, a claim could be that there is no point at all in looking a few years ahead as for (almost) certain, the future will not be exactly as predicted. It is fair to say that this claim is missing the main objectives of carrying out strategic planning, for networks as well as for other areas. Besides being incorrect, the claim disregards the benefits following from a systematic analysis of a company's surroundings and future options.

A motivation for evaluating the coming available choices is to use the results to elaborate a robust action plan to cover triggers for making decisions or to initiate actions as well as optional actions. As described later a robust plan supports a flexible roadmap of system/network evolution, that is what to do for each of the systems given certain factors. Hence, a consequence of this is to try to postpone final decisions until the actions have to be started. This gives the option to not start the action or carry out another action.

In an economic sense, there are at least two motivations why flexibility should be included in an investment evaluation: Firstly, the estimate of the activity value is improved, better reflecting the actual characteristics of the challenge. Another motivation is the improved insight gained for uncertainties and hence a better understanding of the flexibility and the options expected. Commonly real options are applied to include these options in the evaluation. Bringing real options into the equation increases the level of activity values, although the increase differs for the different nature of activities.

The following sections give an overall description of strategy work, both the intention (Section 2) and the overall approach (Section 3). A number of criteria are needed to choose between the different options, as elaborated in Section 4. As presented in Section 5, a sound strategy must also relate to trends at various levels. Section 6 presents how scenario work can be applied in order to assist when deriving strategies, followed by examples in Section 7. A quantitative approach is then given in Section 8. Assessing risk is also an essential element in any strategy as described in Section 9. Some overall discussions are then given in the last two sections.

2 Relating Long and Short Term – the Scope and the Challenges

It is fundamental to understand that the strategic evaluations and planning are not carried out for their own purposes per se, but need to be related to the current situation in order to get practical implications. Naturally a number of steps in the strategy can be located some time ahead, and hence do not necessarily influence today's activities. This means that one result is to sort out the decisions to be made in a timely manner. However, one main result is to devise the actions needed in the actual situation an actor finds itself in. The overall process is depicted in Figure 1.

A number of general steps can be identified:

i. The "frame" of the task is described by the elements: a) Current network portfolio, b) Forecasts and trends, c) Set of (optional) target states. Naturally, these are interrelated as a potential target state is influenced by one's position in the existing situation and a scenario for further development. That is, a scenario-based approach will likely apply for this step. Included in the current portfolio goes also an assessment of short-term development, e.g. given through a "historic" description in the traffic/user development in a system.

ii. The "gap" between the current situation and the target states is explained with a set of possible paths. That is, a path will tell a story for how the current network portfolio will

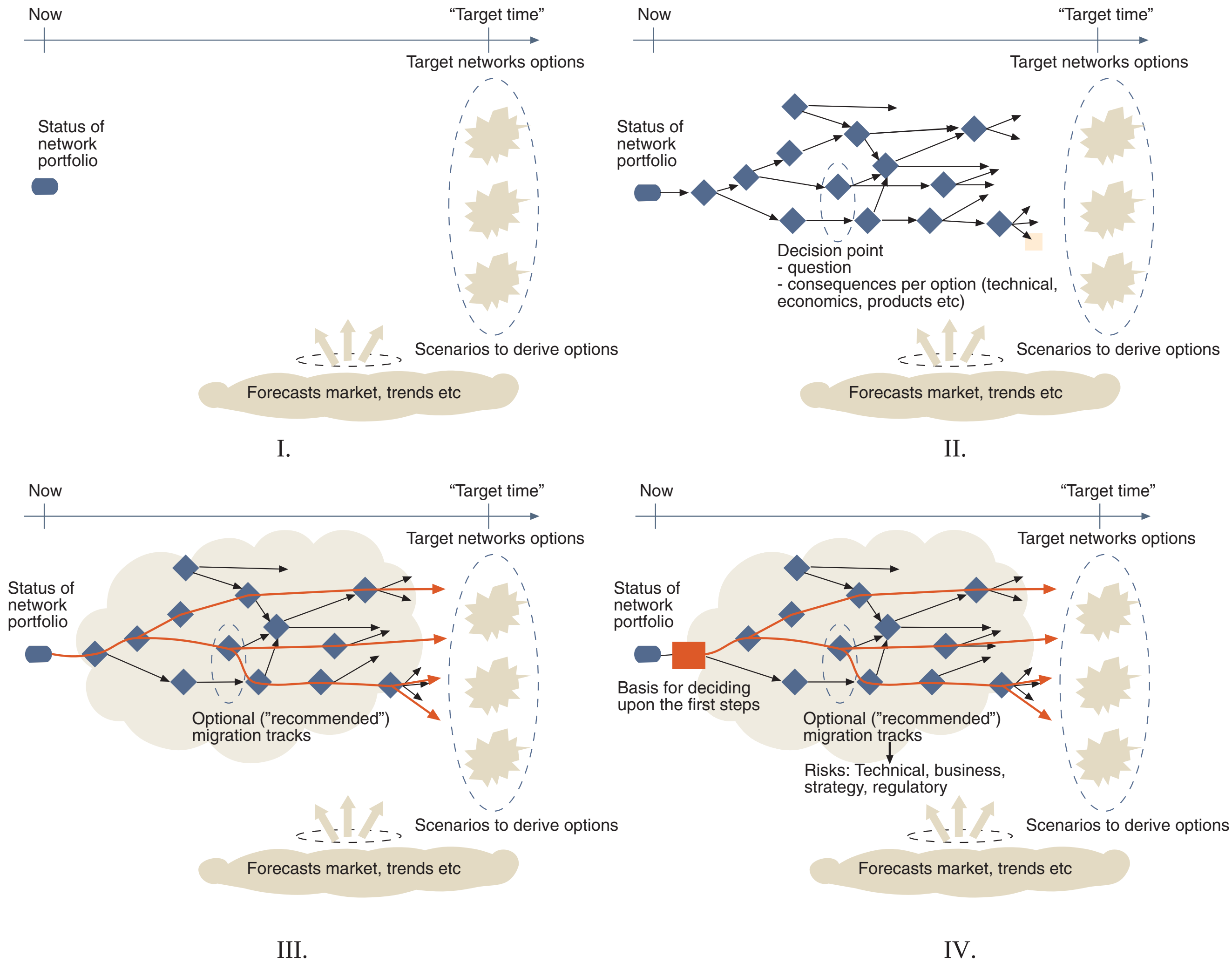


Figure 1 Illustration of step-wise approach using the target options for deriving recommended next steps for today's networks

migrate in order to reach a target state. During a migration, a number of decisions has to be made and solutions implemented. A decision is indicated by a diamond in Figure 1. For each decision, in principle, other choices could have been made, possibly resulting in branches to the path. A decision point should be estimated in time (i.e. when should the decision be made), in addition the relevant question has to be described together with consequences of each of the relevant outcomes of the choices made (consequences in terms of technical, economic, product, etc. issues).

iii. Considering the set of optional (migration) paths and set of decision points, a decision map can be drawn. This then contains the set of candidate paths than can be followed towards the targets. Commonly, quite a few of the theoretical paths are not likely for practical reasons, including financial measures. Hence, a number of real candidates can be described, of which fewer can possibly be recommended migration tracks. These candidates may further be compared according to agreed upon measures, such as net present value, internal rate of return, financial needs, etc.

iv. Looking at the candidate tracks, a number of risk factors can be attached to each track – describing technical, business-related, strategic, regulatory and other risk phenomena. As shown later, these risk factors can be described qualitatively or included in a quantitative way. So, carrying out this exercise, it is essential to relate the observations made to how to make the first step for the current network portfolio. That is, the results are used when making the choice of how to proceed with today's networks. It is also important that the information is revisited and revised as necessary on a regular basis; including the target options, the decision map and the risk evaluations.

Working with a horizon for a given number of years, it is natural to start by gaining insight into trends and key drivers for the network evolution. However, quite a few optional network solutions are expected. Being able to select an appropriate migration of an operator's network portfolio, a set of evaluation criteria has to be defined. To

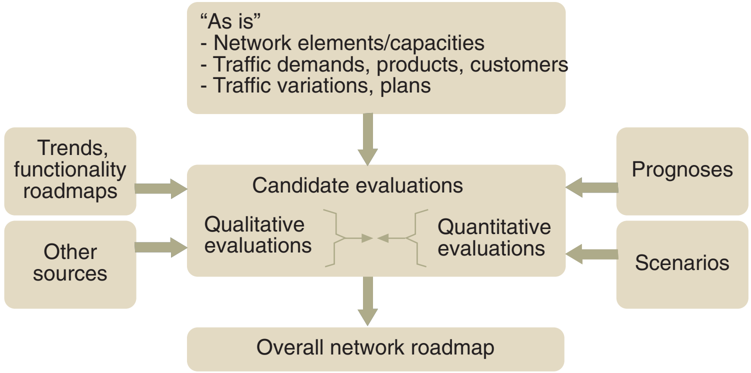


Figure 2 Input and results for evaluation (qualitative and quantitative)

some extent, these criteria can be quantified although some qualitative assessments will also be necessary.

An overall objective of an actor is to level the profit level, both short- and long term. Then, facing the brutal reality of long-term economics, the basic question of which networks and systems to base the operator's future operation on is catching up. As commonly seen elsewhere, managing to terminate a (still) profitable system seems like a harder decision to make than to start up a new system. Hence, the conglomerate of systems that emerge may grow. In addition, several of the systems seem to gradually increase overlap of their application area. This means that in the future more candidates will enter the arena, capable of supporting a spectre of products including those already carried today. One consequence is that the answer to which system to base the future on is steadily more difficult to find.

On the other hand, a few trends seem to dominate the industry, such as IP, optics, DSL and mobile/wireless. But, in view of the current network portfolio managed by an operator and the need to constrain investments and operations to profitable ones, there is still a question in where to invest in order to arrive at a future-proof portfolio. Moreover, the overall risk should be acceptable, considering the profit level sought.

Bearing in mind the overall objective, the goals of the strategic evaluations are to:

- Describe an operator's target network portfolio,
- Identify smart timing of new investments and migration of existing platforms,
- Establish a foundation for decisions on investment and operational aspects to keep a low cost level:
  - Obtain lower overall investment levels, balanced between different areas with corresponding timing (access/transport/service platform, support systems),
  - Ensure complete solutions; consider running costs as well as investments.
- Ensure that an operator maintains the leading position for introducing innovative/holistic network solutions adapted by the broadband market (and others), by enabling rapid service provision.

The priority placed on the different initiatives has to be future-proof, meaning that the steps taken have to fit into a longer-term "journey" approaching a target state of an operator's operation. This basically captures the motivation as well as the overall challenge currently faced by several operators.

3 General Approach

An overall schematic illustration of the strategic evaluation task is given in Figure 2. This is to describe evaluations needed to make the decisions shown in Figure 1. The following main groups of work items are:

a) Description of *status and current plans* ("as-is") for the networks/systems looked at. Configurations at the selected locations are described in terms of network elements (manufacturer, capacity, links, etc.), traffic flows and traffic variation.

b) Elaboration of *optional futures/scenarios* in terms of i) service demands/prognoses, ii) trends for network solutions (and corresponding functionality), and, iii) major uncertain issues (captured by the scenarios).

c) *Other sources*, e.g. from analysis companies, standards, vendors, and so forth.

d) Elaboration of *coherent plans for network roadmaps* considering the dependencies between different systems/networks utilising their strengths.

In order to elaborate plans for network roadmaps the candidates have to be evaluated. For this project, both qualitative and quantitative evaluations have to be conducted. Placing this evaluation in the centre, several inputs have been identified, as shown in Figure 2. The overall results, implying the recommended roadmaps, are then supported by economics as well as functionality arguments, and other arguments related to business and regulatory issues.

4 Criteria for Selecting Migration Branches

4.1 Overall – Financial

In detailing future network candidates, a number of options are revealed in terms of choosing which candidates to base a further network migration on. Hence, there is a need to define a set of criteria to use when selecting which options are the better ones. Some criteria are described in the following.

One basic criterion is the profit levels expected by taking certain steps. Requirements on the expected profit are given considering the accompanying risk level. Hence, higher risk would likely ask for a higher profit level than a lower risk action. Profit can be estimated in different ways. For example, assuming that network solution is irrelevant to income level, the cost of the solution is to be minimised. In general, however, various solutions may support different levels of service and product type. The income side must therefore also be considered in the equation.

A fundamental challenge on the income side is that the price level is influenced by many factors outside the operator considered, such as competitors and regulator. Theoretical models and analyses exist for similar configurations and will not be dealt with in this article.

Concerning financial aspects a number of topics should be looked at, such as:

- Financing needs, e.g. peak funding,
- Value and profitability evaluations, e.g. net present value, internal return rate, payback time,
- Sensitivity analyses of major factors.

As for risks, the technology risk addresses one area. However, a number of additional areas could also be treated:

- Political and market economic risk
- Market and commercial risk (including regulatory)
- Partner risk (also including vendors)
- Financial risk
- Organisational risk (to follow the activities and realise profits)

In order to realise the profit, appropriate steps have to be prepared for in a timely manner, like organisational efficiency, increased revenue, reduced cost, etc. Moreover, exit strategies have to be elaborated to cover alternative steps/paths to follow in case some of the planned steps turn out to be unwanted later on in the process. Which exit strategies that are possible should also be discussed. This corresponds with the map of decision points shown in Figure 1.

The interplay with vendors and customers must also be obeyed. That is, trends among the users have to be observed and possibly matched in order to increase the service demands. Likewise, choices and prioritisations made by the vendors have to be followed, as it could turn out very costly to install and maintain a system from a vendor that is leaving the market or decides not to support that system in the future.

Keeping in mind the broader set of criteria, a few criteria groups are treated in the following (Figure 3):

- Product-related: capabilities of supporting relevant products,

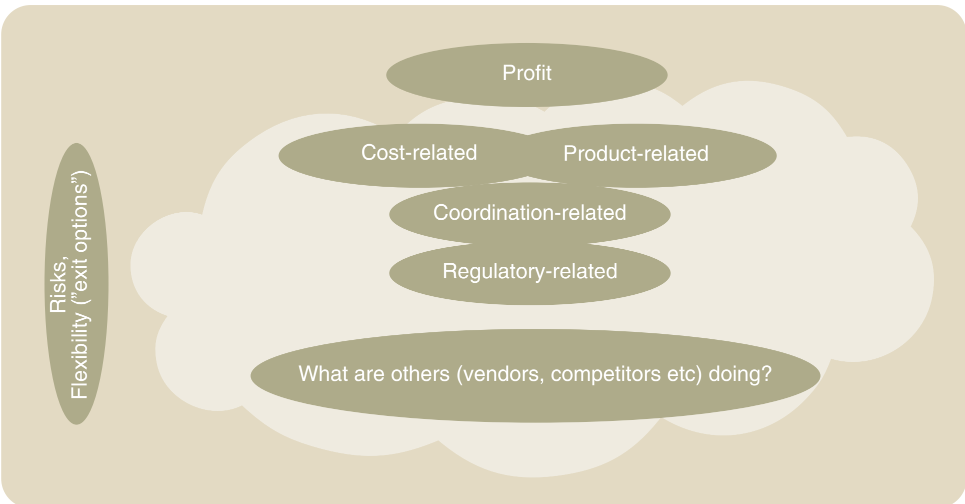


Figure 3 Selected criteria classes

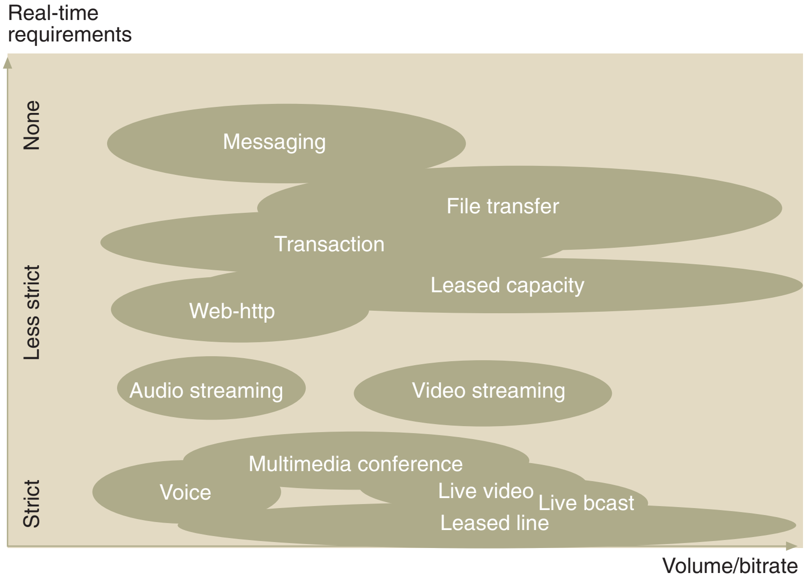


Figure 4 Organising individual end-user services

- Cost-related: the investment and operational costs associated with the network solution (and migration),

- Regulatory-related: would there be any regulatory restrictions or exposure involved,

- Co-ordination-related: are there any effects from the network solutions onto business matters (internal trading, etc.).

The actual criteria weights to use might also depend on the market situation/position, like whether an established operator's situation or a "green field" region is considered. Hence, a somewhat wider scope may be taken on where there is no "history"/legacy systems. To some extent this would also be valid when the overall service portfolio and operation of an actor are looked at – deciding upon which products to offer and which market segments to address. When a set of legacy systems is involved, more emphasis might be placed on managing the systems efficiently and relating the products and systems (production means). This also includes decisions regarding the operations support systems.

4.2 Product-related

All product types relevant for the evaluation have to be considered. This includes not only products seen by end-users, but also products to other operators or departments within an operator when relevant. Moreover, a product may also be bundled together with other products to compose a "new" product.

In the following are treated more product characteristics relating to transport. Basically, such a categorisation could be done in a number of ways. However, to simplify the task, the following factors could be used:

- Timing requirements: Covers real-time requirements, potentially with further variants on timing values (delay and delay variation).

- Volume/bit-rate: The volume is an indicator of the amount of data to be transferred. Considering constraints on the timing, this can also be expressed as requirements on the range of bit-rate needed.

- Interface type/technical solution: Covers types of protocol, etc., and will likely be mostly related to products between operator units.

Some of these may be used to separate products within categories. The timing requirements would likely be a significant factor in addition to the volume/bit-rate. Some concerns may also be related to the content/medium carried and how the two end-points relate to each other (e.g. topology/scope – covering relations between the end-points, like one-to-one, one-to-*N* and *M*-to-*N*).

Some examples using the first two factors are looked at in the following (Figure 4):

- Voice: Carrying speech conversations, which implies interactivity between a set of participants and strict real-time requirements on carrying the voice samples. Currently, most of the voice traffic is carried in PSTN/ISDN and GSM. Typical bit-rates are in the range 8 – 64 kbit/s.

- Live video (VoD): Representing transfer of video in real time between a source and a receiver. This implies fairly strict real-time requirements. Typical bit-rates vary in the area of 500 kbit/s – 6 Mbit/s.

- Multimedia conference: Representing a set of media types (voice, video, text, image, etc.) that are to be transferred between a set of participants in the conference. Typically there are interactivity requirements, although some media types will have less strict real-time requirements. An example of aggregated bit-rates from a single participant is in the range 64 kbit/s – 2 Mbit/s. Some services are offered in a dedicated videoconference network today. In addition, a bundle of ISDN channels may also work as transport. A NetMeeting-like application would also address this product category.

- Video-streaming: Representing the transfer of video content with a play-out buffer in the receiver. Hence, this buffer captures some slack in the transfer-rate variation. The average bit-rate may be the same as video, 500 kbit/s – 6 Mbit/s.

- Audio-streaming: Representing the transfer of audio with a play-out buffer in the receiver. Typical applications would be radio and music. Today radio stations can be listened to through the Internet. Typical bit-rates 16 – 128 kbit/s.

- Web – http: Browsing implies some level of interactivity with a user selecting objects to be transferred. This means some requirements on time for transferring the objects, although no real-time requirements as such. Typical effective (average) bit-rates in the range 15 – 100 kbit/s (although peak bit-rates are higher, say 64 – 500 kbit/s).

- File transfer: This product category covers regular file transfers and more business critical applications, e.g. related to outsourcing. For the latter a high-bandwidth connectivity of 100 Mbit/s or more could be demanded. File transfer represents transfer of (larger) files without real time requirements. Examples of file sizes are 0.5 Mbyte (document), 4 Mbyte (mp3 file), 1 Gbyte (video movie).

- Messaging: Exchange of information between users without real-time requirements. A store-and-forward principle is introduced, allowing for storage of messages in intermediate servers.

- Transactions: Transactions represent messages containing text, images, etc. Examples of volumes are found in the range a few hundred bytes to a few Mbyte. No strict real-time requirements are attached, although an acknowledgement is commonly conveyed to the source.

- Live TV broadcasting: Representing today's broadcasting and future digital systems. Example of capacity is 6 Mbyte per channel. Strict real-time requirements (direction towards the receiver).

- Leased line: Representing leased line services provided, e.g. by the SDH network. Today's bit-rates include 64 kbit/s – 155 Mbit/s and up to wavelengths. Strict real-time requirements are given.

- Leased capacity: Representing a "pipe" from ingress to a set of egress points. Bit-rates may be as for leased line; however, the real-time requirements are less strict.

More detail can be considered when both directions are quantified, see Figure 5. Considering the set of applications used simultaneously also gives indications of which access solutions (bit-rates upstream and downstream) can be chosen.

In several of these products, a number of traffic flows could be involved, each with its separate characteristics. In addition, other aspects could also be considered, including:

- To what extent mobility (and portability) is supported. The highest bit-rates would not be easily provided on wireless/mobile links (except for broadcast networks).

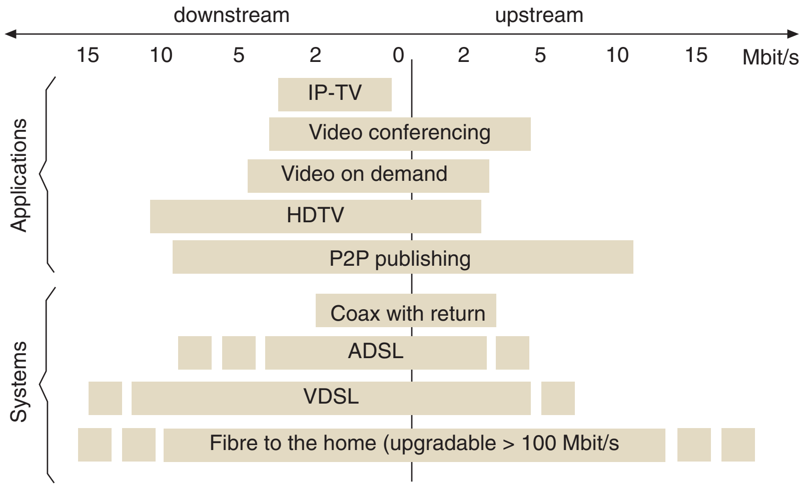
- The topology between the involved communication parties. For conference, multicast and broadcast services, there would be several parties involved. Hence, allowing for multi-party destinations may require corresponding functions in the network. Collection networks may also be considered, where a single receiver gathers information from several sources.

- The dynamics in establishment/release of communication sessions. Two variants are on-demand (controlled by user) and permanent (fully controlled by the operator/provider). Traditionally signalling has been used for the former, while management activities are invoked for the latter. However, a combination of signalling and management procedures may the applied.

- Degree of dependability. Two main dependability measures are availability and reliability. Requirements on dependability may differ for the different products and also vary for the different customer types. An example of a product with fairly high availability is an alarm service (considered to belong to the "transaction" product category).

- For products between operators/providers, these may be aggregation of the end-user products (like for a wholesale operation). The interface type may also be specified. A number of interface types could therefore be specified.

Figure 5 Matching applications to be supported and access solutions (examples)



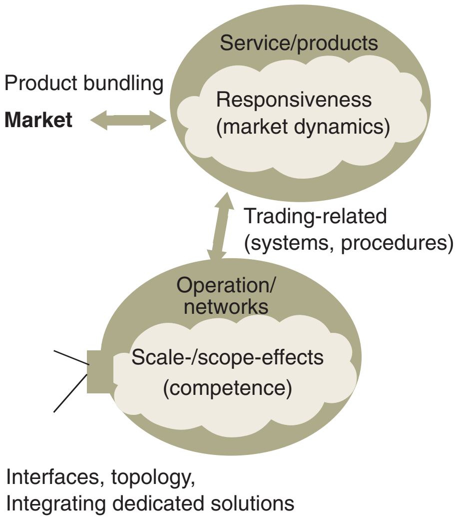


Figure 6 Factors related to co-ordination between an operator's business units

4.3 Costs

There are a number of reasons why a network operator will invest in telecom equipment. Firstly, new equipment could be installed providing the new services that cannot be provided by current systems. Secondly, an existing system could be replaced in order to produce the services more efficiently in a new system. Naturally, the first and the second will also be combined in several cases. A third reason is to expand an existing system in order to cover more traffic load or customers. This is also likely to provide the new versions (and hence a combination of the first and second as well).

The cost components come in various flavours, including:

- Equipment cost – both hardware and software as well as other vendor costs. In several cases recurrent license and maintenance costs are given, or a cost level depending on the amount of traffic/carried load.
- OSS costs, as a consequence of introducing new equipment – this can be either completely new OSS, or adaptations and integration related to existing systems.
- Installation costs
- Operational costs such as:
  - Cost of human resources
  - Other necessary infrastructure (e.g. transport layer support, fibre, copper line, etc.)
  - Necessary vendor support and licenses
  - Training
  - Equipment footprint, reflecting building rental fees
  - Power and cooling requirements
  - Recurring way of right costs

On the other hand, when replacing/modernising an existing system, there is also the potential reuse or sale of redundant equipment which could be taken into the equation. Then, the revenue/income side may also be included in the overall equipment cost calculations.

4.4 Co-ordination-related

For an operator having a wide set of systems, the set of customers to support is also likely to be diverse in terms of requirements. However, there is a steady trend to integrate common solutions, arriving at single systems within an operator, potentially supporting a range of customer segments and product types. This is likely to require co-ordination between business units within the operator in order to successfully deliver services to their respective customers. A simple example is the use of a common IP network supporting both residential and business customers, potentially having different dependability requirements.

A number of factors influence the co-ordination between units co-operating to deliver a product, see Figure 6. The main ones discussed in the following emphasise "trading" between units:

- *Centralisation vs. distribution:* Centralised solutions are better for relatively simple, common tasks with small requirements for individual changes and adaptation. For some other cases, distributing the solutions is the better choice.

  Centralised solutions imply a risk of becoming "least common denominator", i.e. not fully compliant with individual needs. Also, (too) late introduction of new functionality that only applies to some application areas is a potential outcome when focusing on centralised solutions only. The downside of distributed solutions, obviously, is the risk that functions or tasks that otherwise could have been combined, may be duplicated. On the other hand, distributed solutions allow for different time frames when introducing changes and upgrades, taking into account varying "local needs". That is, needs reflecting individual business units.

  As long as the size of the task/area is above a minimum, a distributed solution will be best suited to adapt to variation in requirements and changes in environment. The scale/scope effect, however, would influence the minimum level, including equipment cost/utilisation, human resources, etc.
- *Outsourcing:* Outsourcing a particular task and thus becoming one of several buyers provides some additional challenges:

- A well-defined and professional supplier/ customer relation must be defined.

- The buyer's possibilities of having problems solved rapidly may be reduced.

- The buyer's possibilities of prioritising and controlling error corrections and upgrades are limited.

• *Internal trading:* A "demander" of a certain service within an operator has fundamentally three alternatives: i) buy from an external unit, ii) buy from another internal unit, iii) build it yourself. Whenever constraints are imposed on internal trading (i.e. internal trading has to be applied), the challenges in defining the relationship are particularly great. A healthy climate for internal trading requires freedom and openness for all parties, i.e. any agreement must be commercially viable for supplier and customer. This requires flexibility and incentives for the business units involved.

• *Scale and scope issues:* The following factors may be considered for the scale effect ("the bigger, the better"):

- Co-location of equipment may be easier, including common power supply, ventilation, etc.

- Operation/maintenance staff and gathering of competence

- Planning expertise

- Vendor contacts – prices on equipment and support

- OSS-related – number of systems and need for interconnecting the systems

- Common arrangements for interconnection with other operators/providers

The scope effect, advocating collective functions, may allow for an easier introduction of new products and transfer of products between different networks. Hence, this would affect the service bundling challenge, in particular across different business units' responsibilities.

The co-ordination effects also address a generic challenge for a system design, sketched in Figure 7; the effort spent during the initial design and set-up of a system commonly eases the effort needed to introduce changes to a system. This also goes for the procedures and schemes to follow between units – both within an operator and between the operator and others; an efficiently designed procedure commonly pays back in the long run.

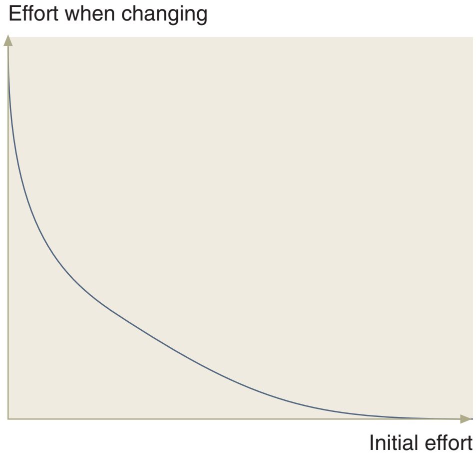


Figure 7 Trade-off effort during initial phase and modification/upgrading/ operational phase

4.5 Regulation-Related (Including Competition)

Providing public telecommunications services and use of radio frequency spectrum are fairly strictly regulated. Operators have obtained licenses in Norway to provide public services. Moreover, a few operators are considered to have significant market power in several areas and thereby have to obey additional constraints, like open and announced conditions for interconnection.

Examples of areas subject to regulation are:

• Provision of public mobile services (NMT, GSM, UMTS)
• Provision of public telephony service
• Provision of leased line services
• Unbundling of local access lines (LLUB)

In addition, an operator may have to obey the Universal Service Obligation (USO) with respect to public telephony, leased line services up to 2 Mbit/s and access to digital telecommunication network (the latter referring to interconnection as opposed to leased line).

Following additional rules due to holding Significant Market Power (SMP) imply that more issues have to be taken care of:

• Transparency
• Non-discriminating
• Cost-based pricing
• Separate accounting for different services

SMP regulation is valid both for fixed network and mobile network services. For these services reporting to the regulating authority has to be taken care of.

5 Trends

5.1 General

Trends can be observed in several areas, including customer demands, market situation and technology/system. Besides these, others may be regulatory, financial, macro-economic, etc. A few samples of trend statements are given in the following. These are by no means exhaustive.

- *Customer demands:* What will customers ask for in the future? Besides being a "million-dollar" question on the business level, it is also a topic that concerns many of the groups engaged in network evolution. A few examples of trend statements are:

  - The overall market for fixed telephony has become rather flat (in terms of revenue) in developed countries and a decrease is expected.

  - The rapid growth of voice in GSM seen previously seems to be taking a break in Western Europe while the steady migration of voice and narrowband traffic from fixed to mobile networks has characterized the last decade.

  - New broadband accesses are primarily based on xDSL. Steadily increasing bandwidth demands due to increased penetration of broadband access and heavier use of the network.

  - Increasingly more cost-oriented business customers, implying a trend of moving towards on-demand services to partly replace leased-line services. This is particularly true for small and medium enterprises (SMEs). Other customers will also look for means to reduce cost, like changing to less expensive interface cards (e.g. Ethernet-interfaces).

- *Market situation:* In several regions, the providers are about to, or have recently gone through a consolidation phase. This implies that several smaller actors have given up or are being bought out by others. On the other hand, there are also several actors entering the telecom area such as the power supply companies and local communities installing high capacity network capabilities at the same time as other facilities are placed into the ground.

  In addition to these come the global players and companies operating in other regions. These may, assisted by their sheer size, be able to operate at lower cost bases, realise higher development capacity and exercise greater purchasing power. Hence, an on-going alliance trend, mergers and acquisitions are expected. At the same time there will frequently be newcomers starting up within certain niches of the market.

- *Technical issues:* Steadily miniaturized electronics allow higher processing power and memory/storage capacity. Hence, more intelligent terminals emerge, including terminal types with potential communication needs. This is seen by wireless communication being integrated in various device types and that machine-to-machine communication seems to grow.

  In the network equipment area, convergence of equipment capabilities is observed. That is, several systems (and vendors) have included most options within their roadmap. Two examples are provision of speech (telephony) and Ethernet-based services. These may be provided by several combinations of network equipment. Another development is manifestation of acknowledged interfaces between modules allowing for interconnecting units from different vendors. It also allows potentially different market segments to converge in the sense that more services can be offered and requested in several segments.

The struggle between services provided and the application of services should also be noted, see Figure 8. That is, services and applications may be seen in a continual pursuit; where the service provider tries to offer adequate services (bundles) while the applications try to utilise expect-

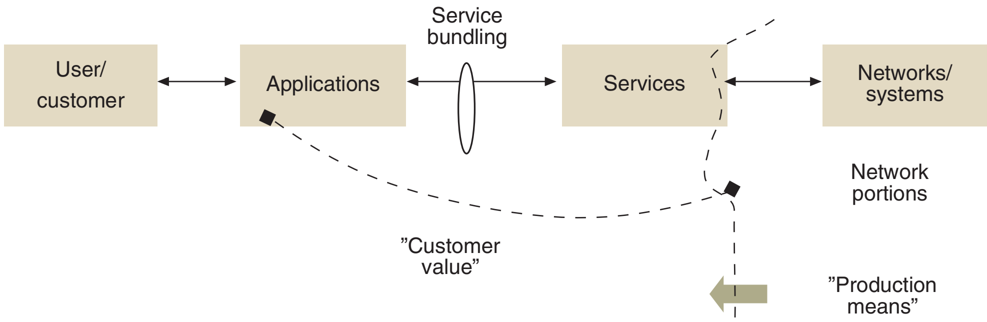


Figure 8 Relation between services (delivered by networks/systems) and applications

	2001		2000		1999	
	revenue (mill NOK)	per cent	revenue (mill NOK)	per cent	revenue (mill NOK)	per cent
Analogue/Digital (PSTN, ISDN, ADSL)	13,668	36 %	12,802	38 %	13,313	45 %
Mobile telephony	9,531	25 %	7,197	21 %	5,468	18 %
Leased line	1,065	3 %	902	3 %	810	3 %
Satellite and TV distribution	3,879	10 %	3,245	10 %	2,584	9 %
Other network-based	2,633	7 %	2,215	7 %	1,593	5 %
IT service and installation	5,009	13 %	4,738	14 %	3,501	12 %
Advertisements, etc.	1,266	3 %	1,555	5 %	1,588	5 %
Others	1,388	4 %	1,040	3 %	987	3 %
Sum	38,439	100 %	33,694	100 %	29,844	100 %

Table 1 Telenor operational-related revenue (excluding asset sales)

	2001	2000	1999	1998	1997
GSM – subscriptions in Norway, end of year					
Fixed subscriptions	1,210,000	1,145,000	1,003,000	944,000	803,000
Prepaid	1,027,000	911,000	732,000	316,000	68,000
Churn rate (related to fixed)	12.5 %	12.7 %	14.2 %	13.1 %	13.9 %
Mobile – originated traffic, Norway, mill. minutes					
GSM	2,969	2,298	1,801	1,279	711
NMT	64	108	174	271	331
ARPU GSM per month, NOK					
Total	340	3,381	341	366	401
Fixed subscriptions	494	473	440	400	401
Prepaid	154	1,652	157	169	0
Telephony lines (fixed) in Norway, end of year					
Analogue (PSTN)	1,527,000	1,680,000	1,908,000	2,167,000	2,324,000
Digital (ISDN)	1,735,000	1,590,000	1,228,000	755,000	410,000
Telephony traffic (fixed) in Norway, mill. minutes					
Domestic, excl. Internet	10,567	11,612	12,371	12,911	11,923
Internet dial-up	4,974	5,667	4,255	2,059	1,079
International	383	387	415	386	379
To mobiles	1,412	1,295	1,246	967	727
Value added services	624	599	447	287	191
Pay-TV, number of subscribers in Nordic, end of year					
Cable-TV	561,000	357,000	282,000	270,000	244,000
Smaller, closed Cable-TV	1,105,000	1,086,000	937,000	686,000	0
Satellite to residentials	657,000	506,000	405,000	352,000	251,000
Total	2,323,000	1,949,000	1,624,000	1,308,000	495,000
Internet, end of year					
Subscribers/registered users, Norway	831,000	625,000	400,000	260,000	165,000
Churn rate (subscriptions)	20 %	25.5 %	14 %	11.7 %	
Nextra business subscriptions, Norway	16,000	13,000	8,000	4,000	2,000
Nextra subscriptions, outside Norway	106,000	104,000	57,000	0	0
Work force, man years, end of year	21,000	20,150	21,968	20,226	19,598

Table 2 Trends in Telenor's operation (from annual report 2001)

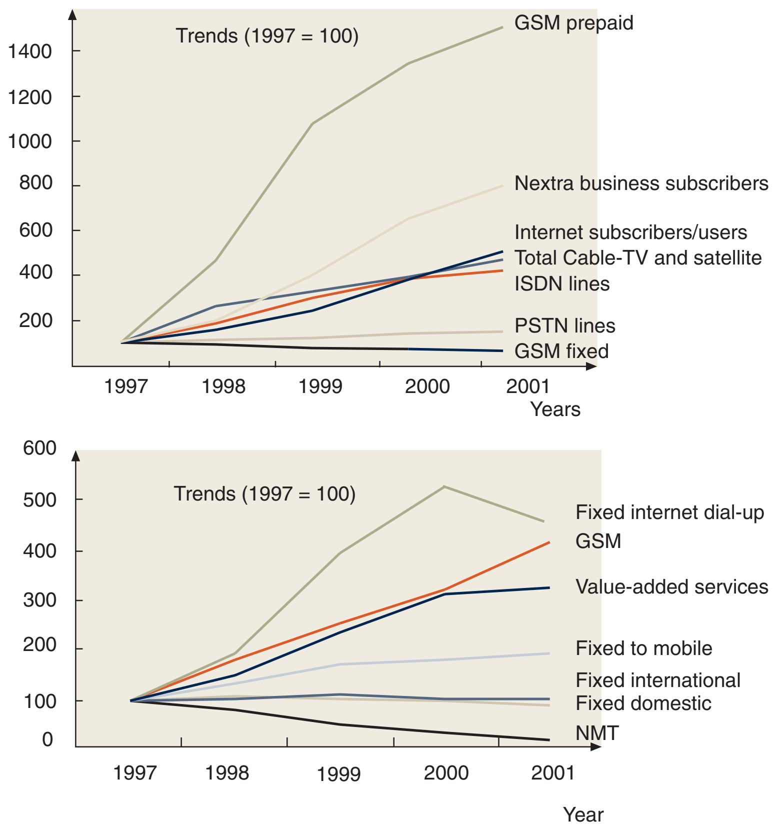


Figure 9 Trends in key indicators, referring to year 1997 as basis (100 – level)

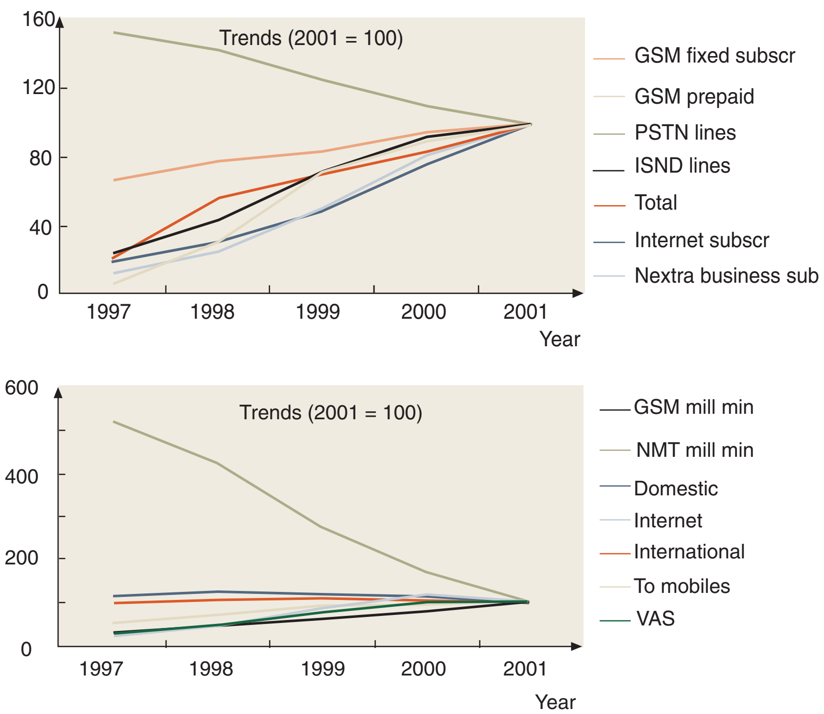


Figure 10 Trends in key indicators, referring to year 2001 as basis (100 – level)

ed (future) services. Hence a spiral effect can be seen, although new technical solutions (and commercial concerns, billing, etc.) may introduce more abrupt changes. Turning it around, in certain areas, this may also be seen as the "chicken and egg" problem.

5.2 Status – Background for Trends

A sound basis for discussing trends of a company is to assess the actual status and concise historic numbers. A few illustrations are given in the following, obtained from Telenor's annual report for year 2001. As a perspective on the dimensions behind different areas of Telenor, Table 1 shows turnover/revenue (million NOK) in 2001 compared to two previous years.

Table 2 gives more technical details, in particular for mobile systems (GSM, NMT), ISDN, PSTN, cable-TV and satellite, and Internet/IP-related operation. Numbers from the years 1997 – 2000 are included to indicate trends.

The numbers clearly point out areas of growth and reductions. In brief, analogue PSTN lines have a fairly drastic decrease, compensated for by the increase of ISDN lines. However, the overall voice-related traffic in PSTN/ISDN has decreased (about 10 % in 2001). Areas of growth are GSM, Internet and cable-TV/satellite in addition to ISDN. As expected, a significant decrease is also seen for NMT (to be phased out a few years after 2001).

The trends are shown in Figures 9 and 10, having year 1997 and year 2001 as basis, respectively. The former emphasises growth areas, while the latter clearer shows the areas in decline.

5.3 System Life-cycle

The different systems have different maturity levels and also address different levels of user needs. Some networks and associated technologies are still in the emerging phase, e.g. ADSL, while others are quite mature, such as PSTN. Traditionally, a system has gone through a competitive growth phase gaining as many customers/coverage as possible by customer acquisition and network infrastructure roll-out. Following that phase, more emphasis is put on revenues per customer, margins, churn rates and OPEX/CAPEX per customer. As a system eventually enters a decreasing phase, the provider's attention is gradually shifted towards customer retention and system consolidation. This is illustrated in Figure 11, also sketching a shift in positions in a future period.

The systems may not follow the same tempo through the different phases. That is, a system might well pass another system, as illustrated, comparing "now" with "*Y* years ahead". During the different phases it is natural that the network development is carried out according to different motivations. However, it is important that the overall life span is considered in the overall network planning avoiding that solutions are chosen that makes the operation very complex or expensive at a later stage.

Another factor is that the decreasing phase should be observed carefully, also reducing the investment levels correspondingly, in order to steer clear of having much surplus equipment towards the end of system life.

Establishing such system life-cycles, scenario exercises are central. The observations made from scenarios will assist also when estimating the tempo of the systems during the different phases. It should also be noted that not every system has to follow the phases, in particular systems that are considered as flops may have difficulty reaching a growing – and hence a mature and declining phase.

6 Scenario Work – Qualitative

One should bear in mind that an approach based on scenario is commonly considered subjective. Hence, several of the steps and choices made may not be uniquely inferred from the previous steps. Still, the scenario approach can be applied to capture a possible future in order to identify the choices that one should prepare for.

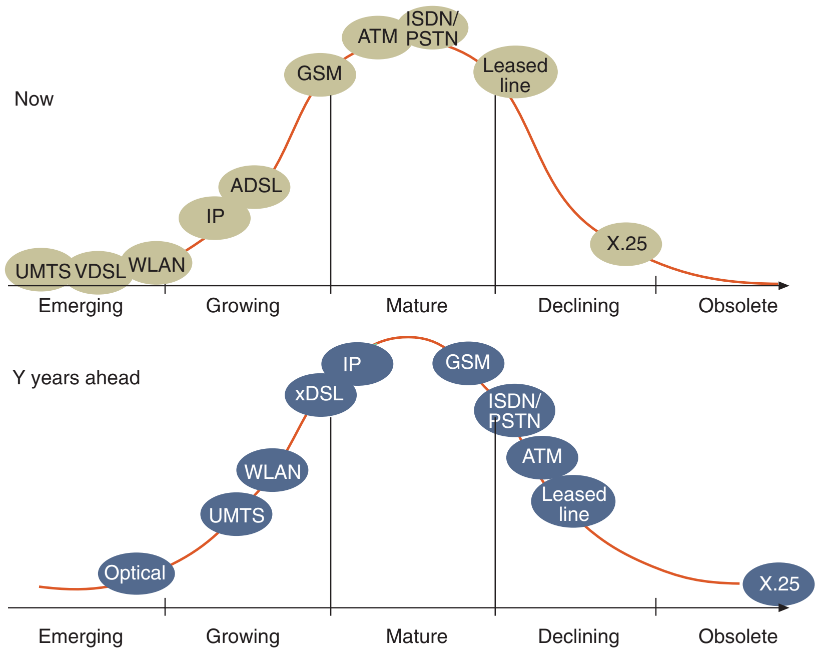


Figure 11 Illustration of system life-cycles; state of the systems today and a possible shift some years ahead

An overall illustration of an approach is given in Figure 12. As shown, the goal is to arrive at network roadmaps. Here the network roadmap shows how the networks in the portfolio should be developed in the time period considered. Hence, for each scenario, a network roadmap is derived. Deriving the network roadmaps, the evaluation criteria and technology time lines have to be taken into account.

Using the sample of network roadmaps corresponding to each scenario, the roadmaps are revisited to find candidates. As expected, fewer sets of candidates are seen than there are scenarios. Hence, these candidates are basis for elaborating a decision tree and the migration plans.

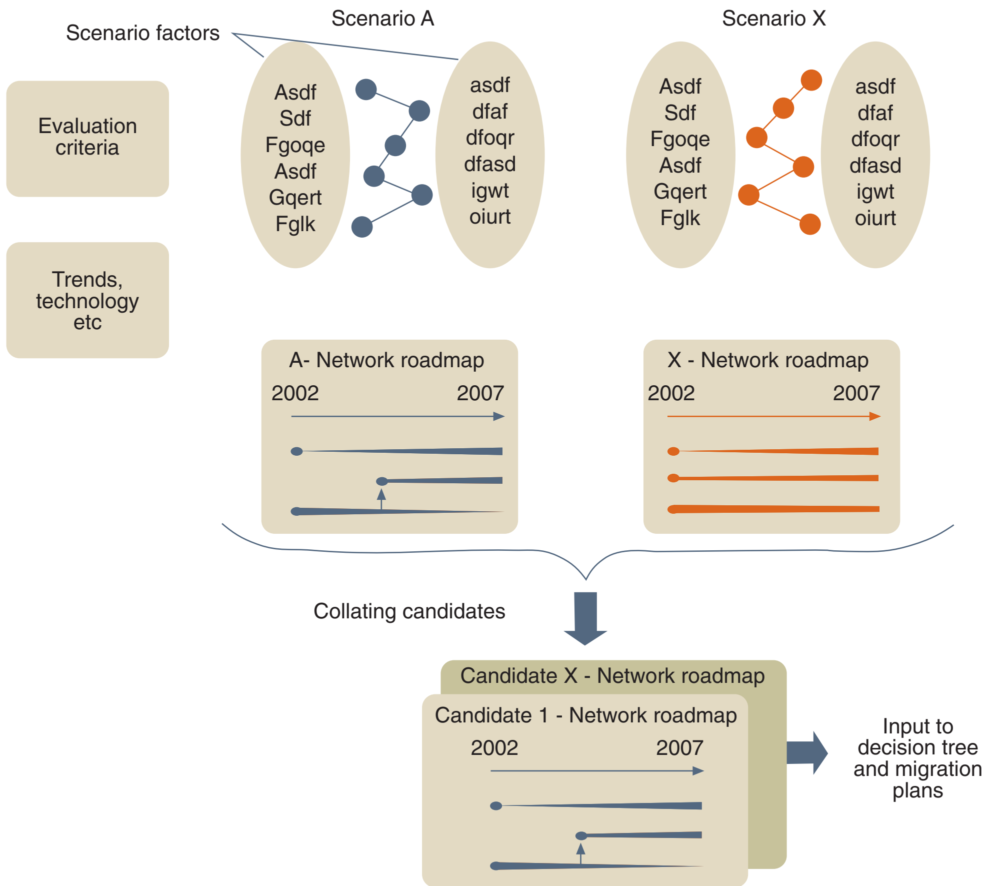


Figure 12 Overall approach followed for deriving candidates for network roadmaps and mapping of product categories (could be iterative)

6.1 Arriving at Scenarios

Deriving a set of scenarios, one faces the trade-off between finding as few scenarios as possible at the same time as the complete feasibility space is covered. Here, the feasibility space refers to all possible situations which may arise in the future. Naturally, a rather limited number of situations have to be selected in order to have a tractable task. Still these situations should include most of the challenges that can emerge. Deriving an adequate set of scenarios may be seen as an art, as several subjectively determined conditions have to be included. However, when open for iterations, one learns for each step, incorporating these lessons when the scenarios are adapted.

In order to describe a scenario, a number of scenario factors have to be defined. These factors will also to some extent assist when exploring whether or not the set of scenarios covers the feasibility space. Again, trade-offs are seen; the factors should be as few as possible (to be tractable) and still capture the main aspects. A high level of subjective judgement is involved when expressing the scenarios by the scenario factors.

A brief scenario description of a scenario definition would then contain:

- List of key characteristics
- Short story of what happened/is happening
- Short description of operator's situation
- Grading of the scenario factors

Even though one would start with a set of scenarios and carry on deriving network roadmaps, it is likely that the scenarios would be adjusted based on the lessons learned. Hence, a few iterations might take place until the scenarios seem to address the most likely and central issues. An alternative would be to derive the scenarios from the scenario factors. Although these factors may not be independent, quite a few combinations will appear, leading to an intractable number of scenarios. On the other hand, these could still be used as a starting point for identifying the scenarios.

6.2 Deriving Network Roadmaps from Scenarios

Given a scenario, certain key characteristics and main trends are included. The idea is then that these would motivate for a corresponding migration of the network portfolio. Again, subjective considerations are behind the story of expressing a network roadmap corresponding to the scenario.

A network roadmap shows how the different network solutions (e.g. ADSL, VDSL, Cable network, WLAN for access network) will migrate and be applied. That is, when new functionality will be introduced (and in what year), and is the specific solution expected to increase, be stable, or decrease in level of importance (number of subscribers, traffic volume, etc.). Moreover, a network roadmap also explains how the different solutions relate to one another. For instance, an IP-based network might be carried directly on an optical network and use ADSL, SHDSL, VDSL, Ethernet and WLAN as access forms.

When devising the network roadmaps, information from the expected trends/time lines as well as criteria is used. For example, the technology trends express views on when certain functions will be available including statements on when the solutions will be applied. This input is a natural starting point to describe the migration, and, considering the scenario characteristics, issues from the technology time lines can be selected accordingly.

6.3 Collating Network Roadmap Candidates

For each of the scenarios, a network roadmap (and product mapping) has to be derived. It is likely that fewer different network roadmaps will appear than the number of scenarios. Therefore, a "reverse processing" could be applied, meaning that the resulting roadmaps are put together. Given that these have the same starting point, they will differ by taking certain (different) steps at certain instances in time. In principle, this can be thought of as a decision tree; facing an instance when two scenarios differ expresses that a decision has to be made. The decisions may also be more related to certain events and less strictly to time instances.

Correlating these network roadmaps with the operator's situation, more figures will be introduced as the method so far has been followed mostly in a qualitative manner. This is done as part of elaborating network migration plans.

To speed up this process, it may be more efficient to start by raising the main questions relating to network migration. That is, devising these questions and then adapting the scenarios correspondingly.

6.4 Scenario Factors

Working on scenarios, a set of factors has to be devised. These factors apply when the scenarios are described, i.e. how the scenarios are placed into the "space" spanned by the factors. In principle, one could use the set of factors to identify potential scenarios. However, considering the set of factors the number of potential scenarios might then become too large.

The work on scenarios would likely be carried out iteratively, meaning that lessons learned from describing scenarios and belonging network roadmaps are used to return to the set of factors and potentially revise them. Note, however, that the scenarios as such are not the main outcome of the network planning, but are mostly used when dealing with the strategic perspective. Still, observations made could well be forwarded to other processes within the operator's sphere.

The scenario factors express the uncertainty attached to a future evolution. Hence, assigning values/grades to a factor "fixes" how that aspect evolves. The factors selected have been formulated as questions; like *A* versus *B*, where *A* and *B* are "opposite" choices on a scale. It is also implied that the scenario description refers to the "environment" as observed by an operator (Figure 13).

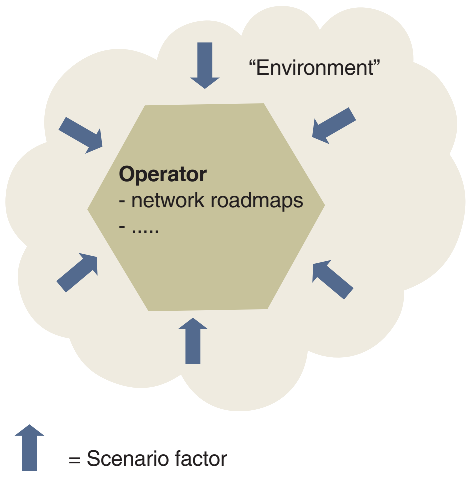


Figure 13 Scenario factors express how uncertain aspects evolve as seen by an operator

In some of the cases the different factors may not be orthogonal (or independent). In these cases, further work may be done to revise the set of factors based on the knowledge gained and the results one wants to look more closely into. Again, however, the scenarios themselves are not considered the main results in the network planning; rather these results are the potential and possibly recommended roadmap of the network portfolio.

Examples of scenario factors and corresponding scenarios are given in the following section.

7 Two Scenario Examples

7.1 Scenario Space With Two Axes

Assuming that one main question is whether or not a common packet-based (core) network should be used to carry the traffic, one should bear this in mind when deriving the scenarios. Here it is assumed that the current situation is to have a TDM-oriented common carrier. These technical combinations are depicted in Figure 14. The blue boxes on top refer to client systems, e.g. ISDN exchanges, ATM switches, IP routers, customer accesses.

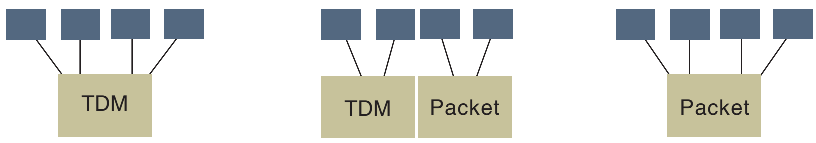


Figure 14 TDM or packet as carrier; left – TDM only, middle – TDM and packet in combination, right – packet only

Then we assume that there are two main uncertainties; i) the technical feasibility of supporting all the traffic on the packet-based network, and ii) the market demand for packet-based services versus more TDM-oriented services. The scenario space could then be made as in Figure 15.

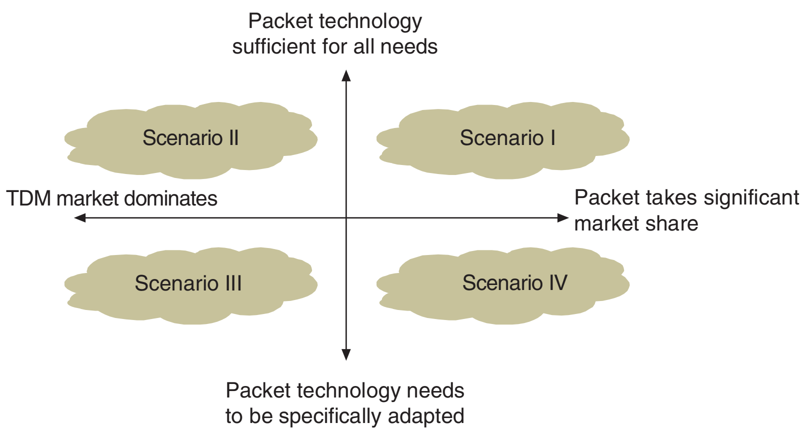


Figure 15 Two axes to illustrate the scenario space

Illustratively the four scenarios can be described as:

- Scenario I: Packet services have taken a significant market share at the same time as packet technology is able to service the demands in a common implementation. Hence, a common packet-based carrier network could be realised, transporting most of the client traffic flows.

- Scenario II: TDM-based services dominate the market although packet technology is capable of transporting the different traffic flows. This could for example happen when the TDM equipment is much cheaper than the packet equipment.

- Scenario III: TDM-based services dominate the market at the same time as the packet tech-

Figure 16 Referring network configurations to scenarios (T = TDM-based, P = packet-based)

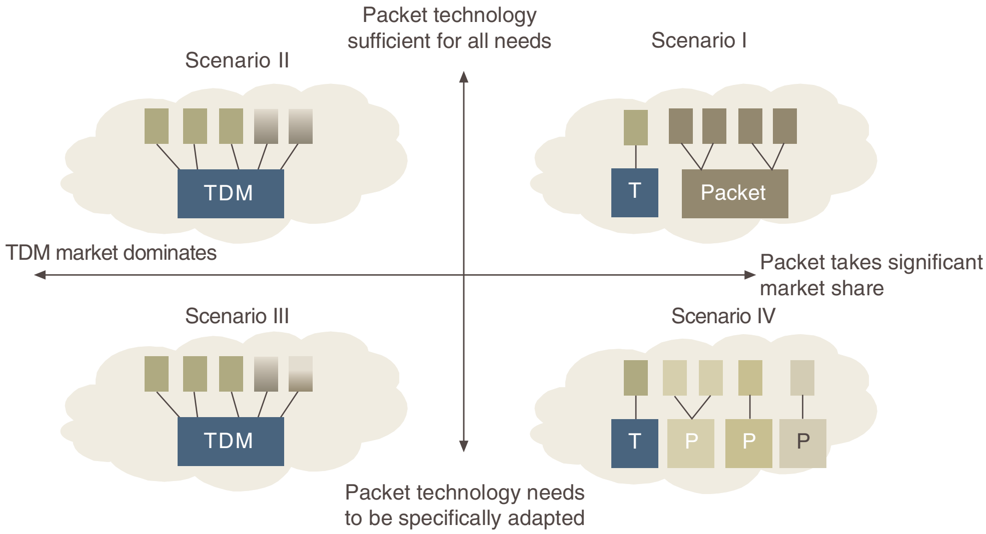
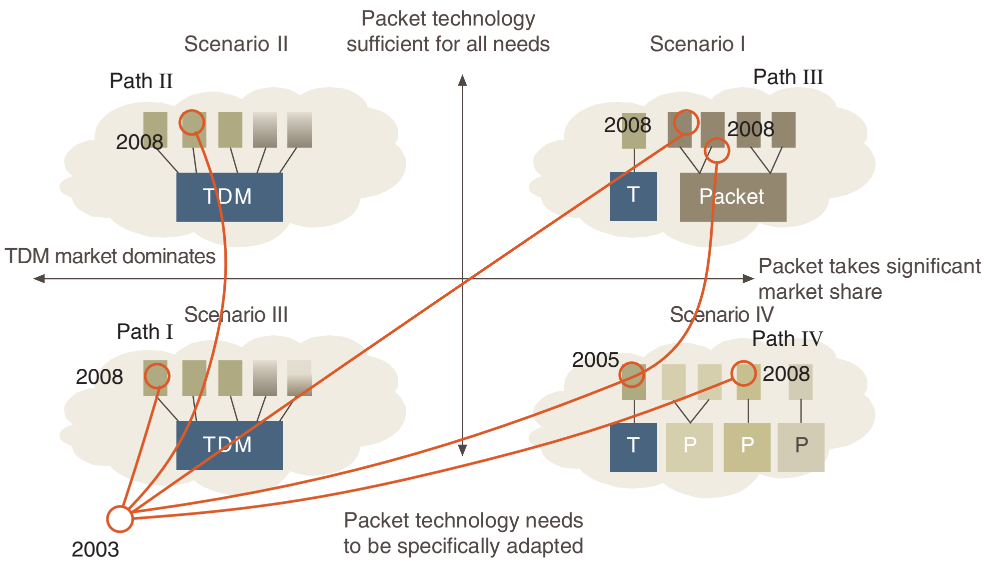


Figure 17 Describing potential network roadmaps referring to the scenarios



nology needs to be specialised to its applications. For example, common packet networks for different market segments cannot be realised.

- Scenario IV: Packet services take on a significant market share, although the packet technology needs to be adapted to its use. This could for example happen if the packet implementation is cheaper than the TDM-oriented way of constructing a network.

The four scenarios can be looked upon as extremes to illustrate the host of possibilities that exist. Practical and optimised solutions from a technical and commercial viewpoint may however show that intermediate solutions between these four are to be preferred.

The network configurations relating to the four scenarios are depicted in Figure 16. Having described these configurations, potential migration paths could be introduced as well. For example, assuming that the current configuration is at the lower left square, theoretically four paths (and hence target states) could be identified, each path reflecting a scenario. A more involved case could be present as well, such as when some of these configurations could be a state on the way towards a target in another square (see path V in Figure 17). Another variation is that the same path is followed in the early migration phases, although one does not reach as far along this path as believed; that is, the target state may be plotted at a closer stage along the migration.

7.2 Applying More Scenario Factors

For a more elaborative scenario description, a number of factors are commonly defined. One example is given in Table 3. Again, it has to be remembered that the most significant factors should be described, which both are chosen based on subjective evaluations and decided by the main network-related questions faced.

Utilising these scenario factors, a number of scenarios can be devised – two examples are illustrated in Figure 18. In addition to grading the scenario factors, a story has to accompany each of the scenarios. This should be a likely explanation how that scenario may occur. Naturally, on the management level, one would also like to know the distribution of market power between the actors present in a market and the roles in the value chain. An illustration of this is given in

Drivers for evolution	Scenario span	
User behaviour	Best-effort data, voice moving to mobile networks	Reach real-time media, seamless mobility
Customer ownership	Network operators	Value-added service providers
Business model	Integrated carriers	Fragmented value chain
Regional balance	US stays leading market	Asia-Pacific drives innovations
Network-or terminal-centric	Intelligence in terminal	Intelligence in network
Regulatory impact	Laissez faire	Strict regulation
Rise of global operators	Fragmented, national	Coordinated, global

Table 3 Example of scenario factors

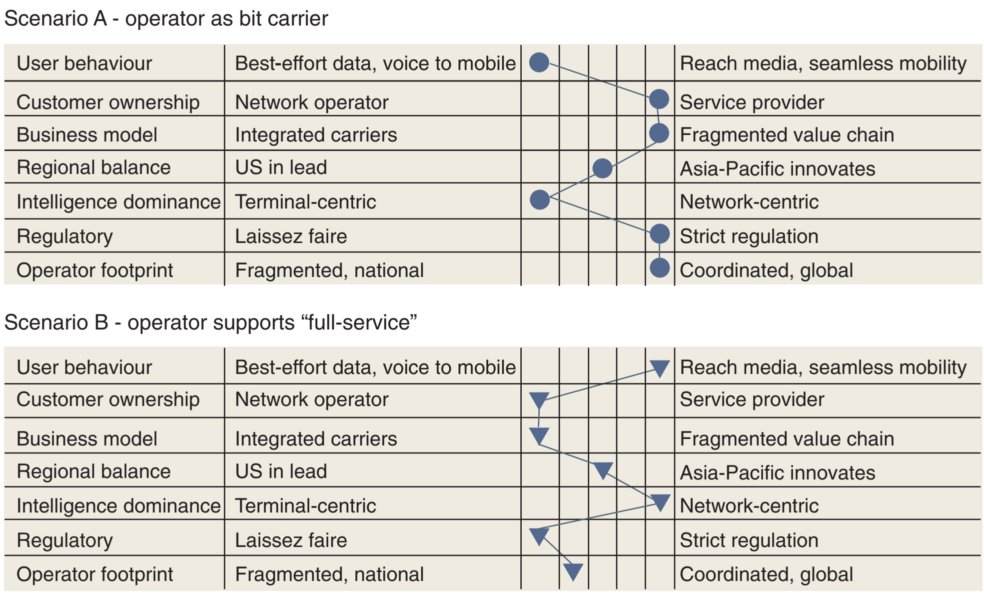


Figure 18 Samples of scenarios defined by the scenario factors

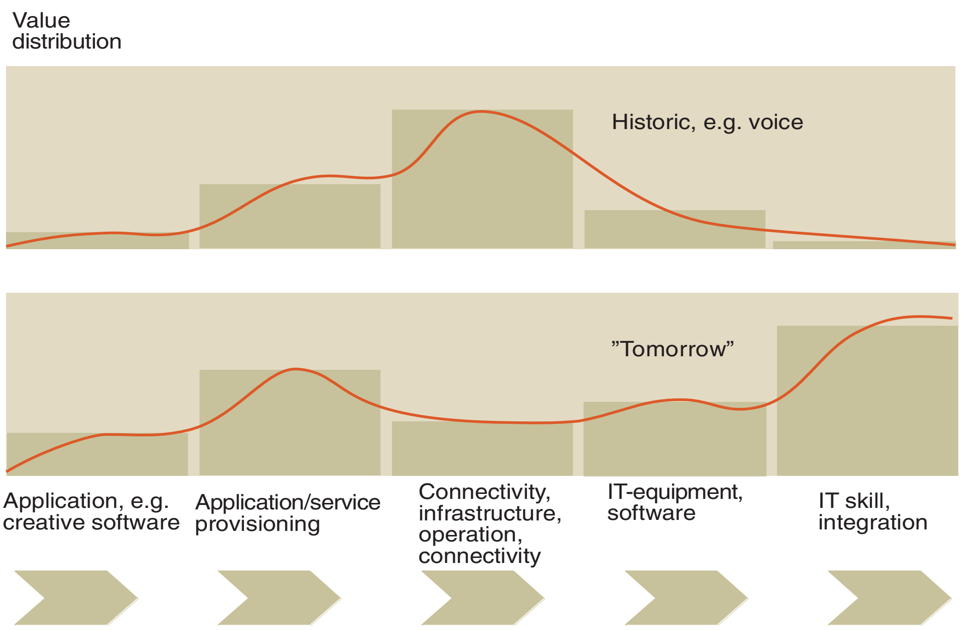


Figure 19 Shift in value chain (although depending on market/competition situation)

Figure 20 *Qualitative illustration of system trends for different access networks related to a set of scenarios*

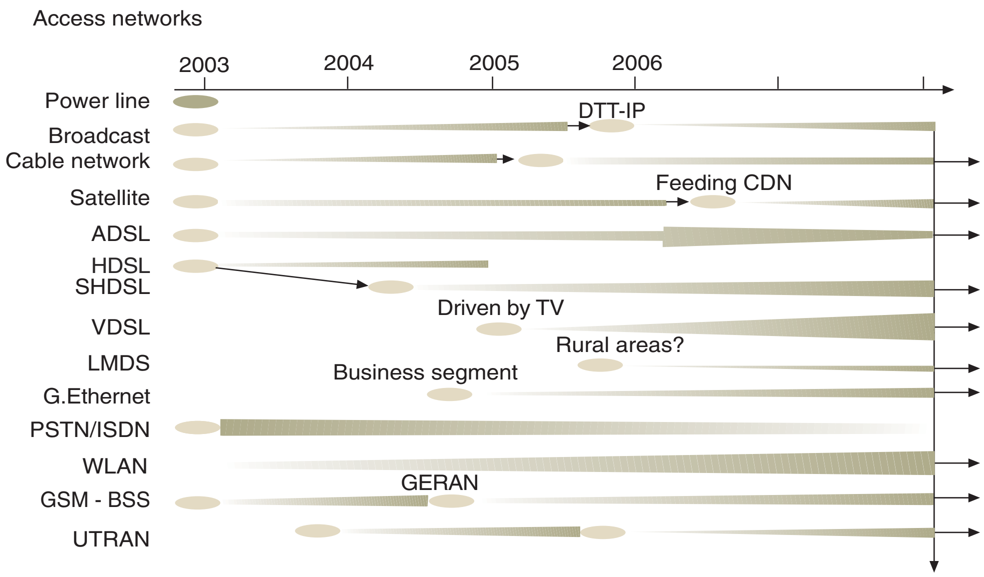


Figure 19, showing a potential shift in value distribution related to a set of scenarios.

After describing the scenarios, actions and consequences on the network portfolio must be derived. Figure 20 shows an example of how a number of access systems could evolve related to a set of scenarios. As described above, each of the scenarios should have a network roadmap associated. Then, these resulting network roadmaps are collated to identify in what manner they differ and the phenomena that influence the decisions to be made for the different systems.

The scenario-based approach provides insight into the factors that influence the system evolution. This is commonly done on a qualitative level. The approach has to be complemented with calculations as described in the following section. The qualitative observations, however, can limit the number of candidates that should be input for the calculations. Moreover, they also try to systematise the uncertainties and risk factors to be followed.

The qualitative evaluations may also reveal a number of "winning systems" that seem to be safe to instal or enhance. This is also a valuable result that should be considered in the following work.

8 Qualitative Evaluations – Calculating Cost of Network Roadmaps

A complete calculation of network roadmaps should ultimately fill requirements for business case studies. However, there is often much uncertainty, particularly related to revenues. The following sections only include the investment aspects. To capture the total cost picture operational expenses must also be considered, given by staffing, license agreements, and so forth.

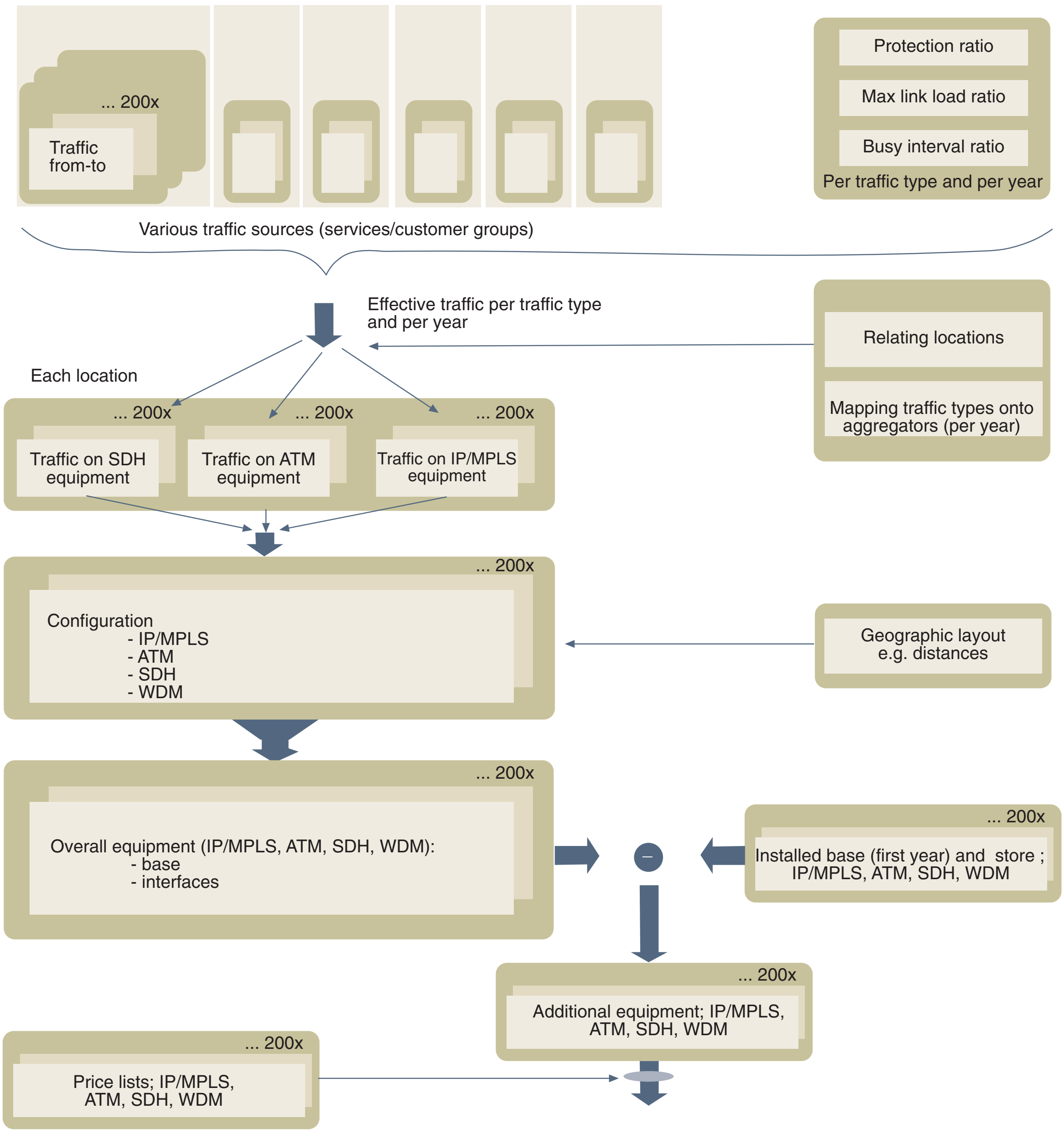
The description is based on an example where the question is how to carry traffic flows for a number of client systems between a number of locations in a core network. However, the same principles apply to other areas as well. Three types are assumed, SDH, ATM and IP/MPLS. These are also referred to as aggregators in the following.

Figure 21 depicts the overall procedure followed when carrying out the calculations. An end-result is the investments needed in order to carry the traffic loads. A study period of a number of years is given, hence, all the major input data must be specified for each of the corresponding years. This also allows for an evolution of the input data, which is essential at least for traffic demands and for component prices.

A major bulk of input data is composed of the traffic matrices specified as traffic load (e.g. in Mbit/s) between the locations (all locations as specified for the network, also giving the amount of traffic to/from abroad). A number of traffic types are specified.

A number of parameters give the dimensioning requirements for each of the traffic types. These parameters are:

- The ratio of traffic that should be kept during a failure situation (in the range 0 .. 1),
- The maximum link load that can be realised (in the range 0 .. 1),



Investment/ economics

Case	Investment in Mill. NOK								
Investment	2002	2003	2004	2005	2006	2007	Spare equip.	Invest -Spare	Sum 02-07
IP-related	9.6	2.9	4.7	6.5	11.3	8.6	4.9	38.7	43.6
SDH-related	3.2	0.7	2.3	0.0	0.9	1.5	0.0	8.7	8.7
ATM-related	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WDM-related	1.1	0.5	1.1	3.2	3.4	5.2	0.0	14.6	14.6
sum	14.0	4.0	8.2	9.7	15.7	15.3	4.9	62.0	66.9

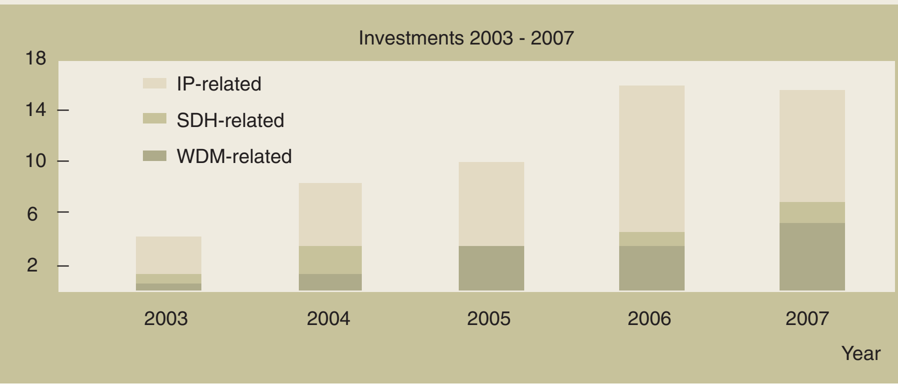


Figure 21 Schematic flowchart for calculations

- The relative portion of the peak traffic load that is present in the dimensioning interval, i.e. a busy interval indicator (in the range 0 ..1).

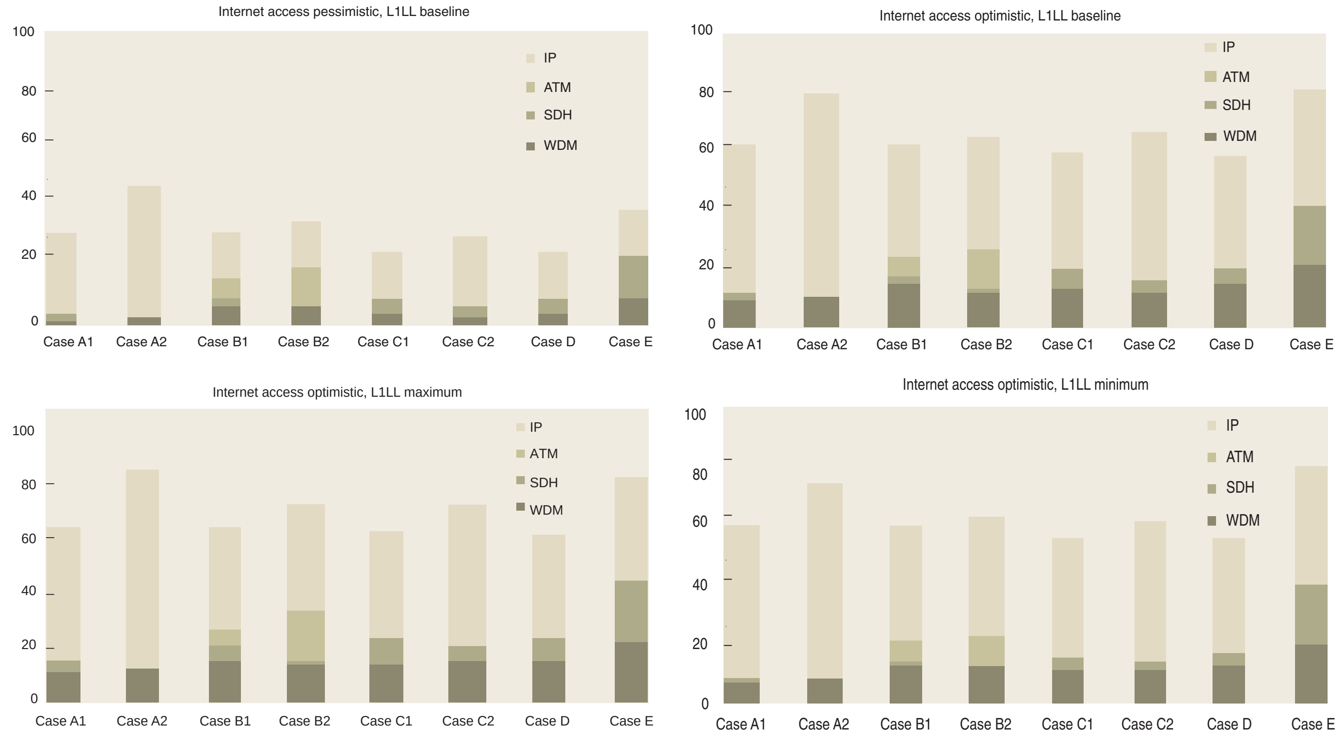
In combination, the two former indicate the traffic situation during a failure situation. For instance when a failure occurs, a ratio of the traffic (on the failed link) is carried by an alternative link and the maximum load on that link is given by the "maximum link load" parameter.

The result of taking these parameters into account is called the effective traffic load. This traffic load is given for each traffic type and each year. A step further is to consider the relations between the locations. This means to consider where links are placed (present between certain locations). Relating the effective traffic loads, mapping of traffic types onto aggregators and presence of links decide the traffic load on each aggregator type at each location.

The traffic loads on the aggregators give the configurations of each aggregator. "Directions" must also be included (that is where links are going) as well as the distances between the locations (in particular for WDM equipment).

Adding equipment types on all locations gives the overall needed equipment (for base configuration, interfaces, etc.). In order to consider actual deployment and equipment reuse between different years, an "equipment store" is present. Hence, only when needed equipment of a certain type in a year exceeds the sum of that equipment type in the previous year and the number in the "store" is additional equipment bought.

The result after looking at installed equipment, "stored" equipment and needed equipment is a list of additional equipment that needs investment funds. Considering the price of that equipment for the corresponding year gives an investment level. These investments can be aggregated in different ways, for instance per equipment class, per year, for the whole period, etc.



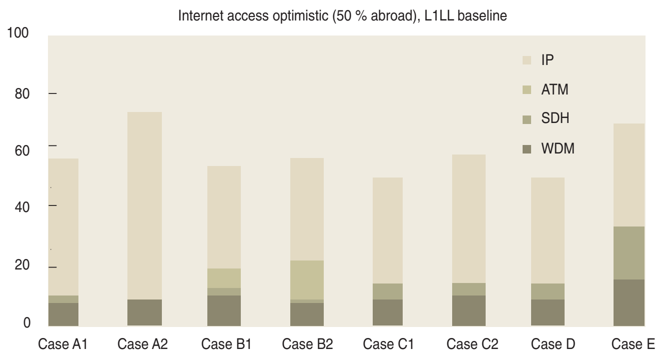


Figure 22 Costs of IP/MPLS, ATM, SDH and WDM equipment for cases and demand variations

In addition to economic output, traffic and capacity results can also be recorded.

Typically, calculations are carried out for a number of cases and the results are compared. These cases can be specified by the technology used, years for introducing functionality, variation in traffic demands, changes in equipment prices, and so forth. In addition different network architectures would be examined. An intention is to find out the more critical parameters, that is, those significantly influencing the results and the network roadmaps that should be preferred. At the end of the calculation period, the installed equipment could be assigned a value ("terminal value") depending on how investment levels should be estimated.

For most transmission systems the capacity often comes in certain granularities, e.g. 155 Mbit/s, 622 Mbit/s for SDH. This has to be included in addition to any consequent costs such as management systems and installation work.

An example of investment results is given in Figure 22. These are shown for five different combinations of traffic demands and where eight cases are examined (A1, .., E). One reason behind breaking up the investment cost showing network types is to give ideas on where more investment savings could be obtained.

An immediate observation from the results above is the fairly high ratio of costs relating to IP/MPLS equipment. In order to look more closely into the effect of varying costs of this equipment the following calculations were conducted; all IP/MPLS equipment costs were changed by *x* % (in the interval from –75 % to +50 %). Only cases A1, A2 and D are shown in Figure 23 as the objective was to estimate points of intersections. Two demand variants are included: Internet access pessimistic + L1LL baseline and Internet access optimistic + L1LL maximum.

For the variant 'Internet access optimistic + L1LL maximum' cases A1 and D come out with equal overall investments when the IP/MPLS cost is reduced by 25 %. For other combinations the IP/MPLS costs have to be reduced by about 75 % in order for the lines to intersect.

9 Risk Analysis and Exit Strategies

As described earlier, a number of decisions will commonly be revealed during the network strategy evaluations. For each step, a certain risk level is associated. In this section a general introduction to incorporate risks into the evaluation given.

9.1 Risk – General Introduction

Considering the constant change and uncertainty, an integrated risk management practice within an organisation is required to strategically deal with uncertainty and thereby capitalise on opportunities. The stakeholders in the decision process will also be involved in order to ensure better decisions in the future.

A risk management arrangement should cover all types of risks that face the organisation, including policy, operational, human resources, financial, legal, health and safety, environment, reputation. Hence, it is essential to integrate risk management into strategic decision-making. By establishing a risk management framework, a mechanism will be in place allowing to discuss, compare and evaluate different risk types.

Deploying a risk management regime also allows for a so-called risk-smart workforce that supports innovative and responsible risk-taking while ensuring legitimate precautions.

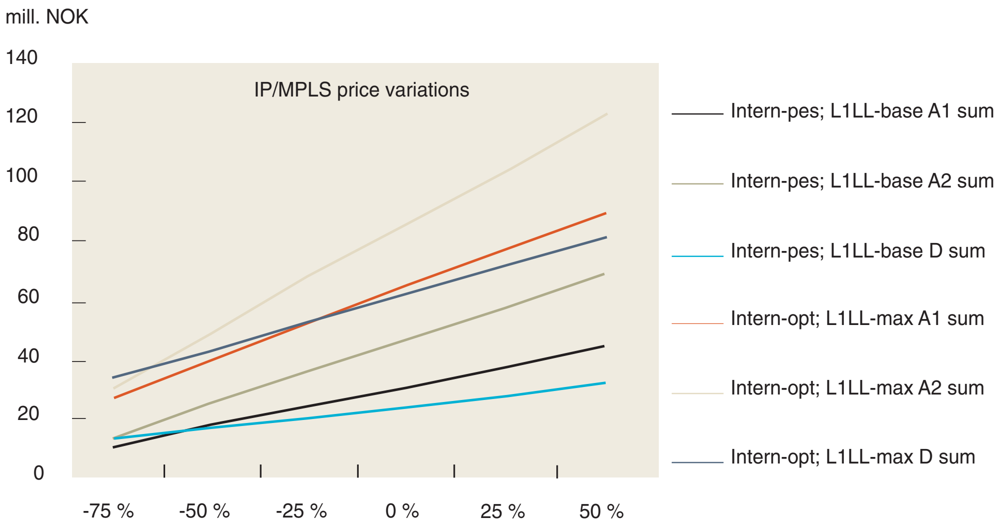


Figure 23 Impact on IP/MPLS cost variations for Cases A1, A2 and D

Risk is unavoidable and present in almost every situation in every-day life, for private as well as business roles. A number of definitions of risk are in use. However, a common concept in all definitions is that a certain level of uncertainty of the outcome is involved. One way the definitions differ is the characterisation of the outcomes; some describe risk as having only adverse consequences, while others are neutral. An ongoing discussion takes place arriving at an acceptable (common) generic definition of risk that recognizes the fact that when assessed and managed properly, risk management can lead to innovation and opportunity. This appears even more prevalent when dealing with operational risks and in the context of technological risks. One definition found is *the expression of likelihood and impact of an event with the potential to influence the achievement of an actor's objective*. Hence, risk refers to uncertainty around future events and outcome.

Other definitions found are e.g.:

- Combination of the probability of an event and its consequences. Note – in some situations, risk is a deviation from the expected,

- The chance of something happening that will have an impact on objectives. It is measured in terms of consequences and likelihood,

- The chance of injury or loss defined as a measure of the probability and severity of an adverse effect to health, property, the environment or other things of value,

- The possibility that one or more individuals or organizations will experience adverse consequences from an event or circumstance.

A risk measure can be formalised as

$$risk = \sum_{event\_i} probability(event\_i) \cdot consequence(event\_i)$$

The summation is taken over all events considered and the product of each event's probability of occurring and consequence is added.

In order to take advantage of the present risk factors a management framework should be introduced. Risk management is defined as a systematic approach to setting the best course of action under uncertainty by identifying, assessing, understanding, acting on and communicating risk issues. As risk management is directed at uncertainty related to future events and outcomes, it is implied that all planning exercises encompass some form of risk management. Risk management is also impacting people at all levels as it concerns making decisions that contribute to the achievement of an actor's objectives. Hence, integrated risk management is a continuous, proactive and systematic process to understand, manage and communicate risk from an actor-wide perspective. It is about making strategic decisions that contribute to the achievement of an actor's overall corporate objectives. Integrated risk management requires an ongoing assessment of potential risks. Hence, it should be embedded in the actor's strategy and risk management culture. As stated above it is not limited to minimising the risks, but rather to foster innovation in order to achieve greatest returns with acceptable results, costs and risks. Hence, an optimal balance is strived for at the corporate level.

As pointed out in [Cari01], four key elements are included in an integrated risk management framework:

1. Develop the corporate risk profile – considering objectives and available resources
   a. Identify risks; resulting in description of threats and opportunities, i) type of risk – technological, financial, human resources, health, ii) source of risk – external, internal, iii) what is at risk – area of impact/type of exposure, iv) level of ability to control the risk – high (operational), moderate (reputation), low (natural disasters).

   b. Assess current risk management status; resulting in descriptions of challenges/ opportunities, capacity, practices.

   c. Identify risk profile; description of key risk areas, risk tolerance, ability and capacity to mitigate and needs for learning. In general, there seems to be lower risk tolerance for the unknown, where impacts are new, unobservable or delayed. In addition a higher risk tolerance is observed where people feel more in control (e.g. for car travel compared to air travel).

2. Establish an integrated risk management function
   a. Communicate, understand and apply management direction on risk management; risk management needs to be aligned with an actor's overall objectives, corporate focus, strategic direction, operating practices and internal culture. When a strategic risk management direction is set up, both internal and external concerns, perceptions and risk tolerances are taken into account. It is imperative to identify acceptable risk tolerance levels so the unfavourable outcomes can be remedied promptly and effectively.

b. Implement operational integrated risk management through existing decision-making and reporting structures. Integrating the risk management function into existing strategic management and operational processes ensures that risk management is an integral part of day-to-day activities.

c. Build capacity through development of learning plans and tools. Building risk management capacity is an ongoing challenge even after integrated risk management has become firmly entrenched. Environmental scanning will continue to identify new areas and activities that require attention, as well as the risk management skills, processes, and practices that need to be developed.

3. Practise integrated risk management
   a. Consistent application of common risk management at all levels. A common, continuous risk management process assists an actor in understanding, managing and communicating risk.

   b. Integrate results of risk management practices at all levels into informed decision-making and priority setting

   c. Apply tools and methods

   d. Consult and communicate with stakeholders

4. Ensure continuous risk management learning
   a. Establish supportive work environment where learning from experience is valued, and lessons are shared

   b. Build learning plans into actor's risk management practices

   c. Evaluate results of risk management to support innovation, learning and continuous improvement

   d. Share experiences and best practices

A potential risk management process wheel is illustrated in Figure 24. Internal and external communication and continuous learning improve understanding and skills for risk management practice at all levels of an organisation, from corporate through to front-line operations. The following steps may be included in a risk management process (from [Cari01]):

A. Risk Identification

1. Identify issues, set context:
   - Define the problems or opportunities, scope, context (social, cultural, scientific evidence, etc.) and associated risk issues.
   - Decide on necessary people, expertise, tools and techniques (e.g. scenarios, brainstorming, checklists).
   - Perform a stakeholder analysis (determine risk tolerances, stakeholder position, attitudes).

B. Risk assessment

2. Assess key risk areas:
   - Analyse context/results of environmental scan and define types/categories of risk to be addressed, significant organisation-wide issues, and vital local issues.

3. Measure likelihood and impact:
   - Determine degree of exposure, expressed as likelihood and impact, of assessed risks, choose tools.
   - Consider both the empirical/scientific evidence and public context.

4. Rank risks:
   - Rank risks, consider risk tolerance, use existing or developing criteria and tools.

C. Respond to risk

5. Set desired results:
   - Define objectives and expected outcome for ranked risks, short/long term.

6. Develope options:
   - Identify and analyse options – ways to minimise threats and maximise opportunities – approaches, tools.

Figure 24 A potential risk management process (adapted from [Cari01])

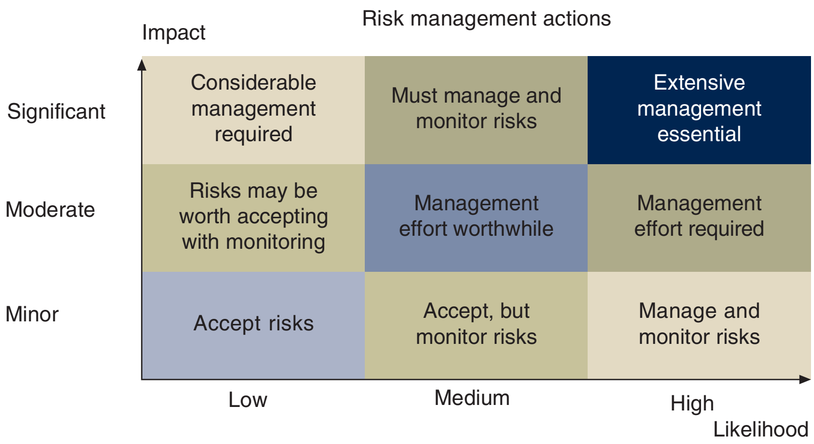


Figure 25 A potential risk management model

7. Select a strategy:
   - Choose a strategy, apply decision criteria – result-oriented, problem/opportunity driven
   - Apply, where appropriate, the precautionary approach/principle as a means of managing risks of serious or irreversible harm in situations of scientific uncertainty.
8. Implement the strategy:
   - Develop and implement a plan.

D. Monitor and evaluate

9. Monitor, evaluate and adjust:
   - Learn, improve the decision-making/risk management process locally and organization-wide, use effectiveness criteria, report on performance and results.

Each function or activity considered has to be examined from three perspectives:

- Its purpose: risk management would look at decision-making, planning, and accountability processes as well as opportunities for innovation.
- Its level: different approaches are required based on whether a function or activity is strategic, managerial or operational.
- The relevant discipline: the risks involved with technology, finance, human resources, and those regarding legal, scientific, regulatory, and/or health and safety issues.

A number of techniques can be used to assist in risk management, including:

- Risk maps: summary charts and diagrams that help organisations identify, discuss, understand and address risks by portraying sources and types of risks and disciplines involved/needed.
- Modelling tools: such as scenario analysis and forecasting models to show the range of possibilities and to build scenarios into contingency plans.
- Framework on the precautionary approach: a principle-based framework that provides guidance on the precautionary approach in order to improve the predictability, credibility and consistency of its application across several units.
- Qualitative techniques: such as workshops, questionnaires and self-assessment to identify and assess risks. Internet and organisational intranets: promote risk awareness and management by sharing information internally and externally.

Each assess risk can be illustrated according to its likelihood and impact as depicted in Figure 25.

9.2 Risk Allocation – Quantitative Aspects

In principle, two risk types can be defined, depending on the source of the risk:

- Systematic risk – coming from influences on the "market" in general. An example is change of interest rate.
- Non-systematic risk – coming from other sources than those affecting the "market" in general.

Considering a portfolio, the risk can be described by its exposure to the systematic factors, the volatility of those systematic factors, and the residual (or non-systematic risk). Regarding the systematic factors, an actor can gain passive exposure to these with little effort (or cost).

The non-systematic risk, in contrast, comes from the on-going decisions actors make in managing portfolios over time. When the actor is actively revising portfolio exposure to sources of systematic risk, these decisions generate non-systematic risk in a portfolio in addition to any systematic risk embedded.

The pay-off for bearing risk is commonly scaled according to the level of risk assumed. For systematic risk, the ratio involves dividing the risk premium by the level of systematic risk:

$$Sharpe\ ratio = \frac{Risk\ premium}{Systematic\ risk}$$

For non-systematic risk, the ratio involves dividing the non-systematic return by the level of non-systematic risk. This ratio is often referred to as the Information Ratio (IR):

$$IR = \frac{Non - systematic\ return}{Non - systematic\ risk}$$

For a portfolio, the return (pay-back) effects are additive between systematic and non-systematic risk. Hence, in variance terms:

$$\sigma^2_P = \sigma^2_S + \sigma^2_N + 2Cov_{SN},$$

where σ^2 indicates the variance (subscripts: P – total portfolio excess return, S – systematic excess return, N – non-systematic return) and Cov_{SN} indicates the covariance between the systematic and non-systematic returns.

For a typical well-diversified portfolio, the non-systematic risk makes up a relatively small portion of the total variance of the portfolio's return.

For an actor to allocate total risk in a portfolio between systematic and non-systematic sources, it is important to know the sources of risk for each alternative strategy that is considered as a candidate for inclusion in the portfolio. An important characteristic of most alternative strategies is that a greater portion of the total risk comes from non-systematic risk instead of from systematic risks.

An actor has the decision of how to i) allocate the risk budget across systematic factors, and ii) establish trade-off between systematic risk and non-systematic risk. This is the case even if the investor is not considering investing in any non-traditional strategies.

In these discussions it is essential to estimate the expected return from active management of each strategy (to exploit the non-systematic factors). One source of the expectations is the historical performance of different types of actively managed strategies. In some segments, possible gains may be high, while in other segments, there is less opportunity for additional gains.

An expected information ratio may support the understanding of actively managed portfolio. This can be illustrated as:

$$IR = \frac{E[\alpha]}{\sigma_\alpha} = IC \cdot TC \cdot \sqrt{N},$$

where:

IR = information ratio
$E[\alpha]$ = expected non-systematic return
σ_α = non-systematic risk
IC = information coefficient
TC = transfer coefficient
N = number of decision points (often referred to as the breadth)

The information ratio is commonly a measure of how much non-systematic return that is expected relative to the amount of non-systematic risk. In general it is more preferable to obtain a higher information ratio:

- The information coefficient indicates how accurate the actor is in forecasting future returns. This is commonly estimated by computing the correlation between forecast returns and subsequent non-systematic returns. Different options with a high level of predictability have higher ICs than those with lower level of predictability.

  When an actor wants to increase the information ratio of an active strategy, this is to increase the information coefficient, either by finding better predictors of future relative returns or by recruiting individuals with better insight than others. Given the competitive nature of the market it is not that easy to increase the information coefficient.

- The transfer coefficient indicates how efficiently the actor's information is used in forming portfolio positions. The more constraints that are placed on the portfolio, the lower the transfer coefficient usually becomes. In a general case, constraints are commonly placed on the size of individual positions or combinations of positions (e.g. engagements in different countries, obligations to provide services, etc.). Relaxing any of these constraints tends to increase the transfer coefficient and improve the information ratio.

- The breadth indicates how many opportunities the actor has in applying the information gained. Hence, this shows the number of decisions that can be made during a process. This number is a function of both the number of elements in the portfolio and the frequency of decision-making. On the other hand, there is often a cost side of increasing the frequency of decision (such as preparing decision basis).

Considering these factors, in terms of risk budgeting, it is observed that a greater amount of non-systematic risk is allocated to the strategies that: i) focus on more inefficient markets (higher expected information coefficient), ii) are subject to fewer restrictive constraints (higher transfer coefficient), iii) have greater breadth (combination of a large universe to choose from and high frequency of portfolio management decisions).

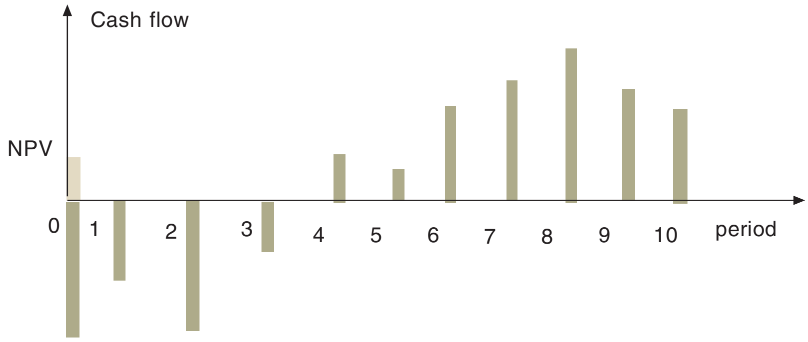


Figure 26 Net Present Value capturing the cash flow of an activity for a number of periods

9.3 Associating Gains with Options/Choices

On the one hand, relating to uncertain factors represents a risk to be included in the evaluation. On the other hand, in case a final decision can be postponed until more information is available, one would also consider a future option to decide as a positive effect. Hence, the latter should be included in the evaluation of a portfolio consideration where all future decisions could be added to the overall calculations.

A fairly standard way of evaluating an activity is to apply the Net Present Value (NPV). This measure collapses an activity's monetary timely schema into a single value. This is done by adjusting future cash flows and reflecting them into a current time value, see Figure 26.

Noting the cash flow in period *i* by CF_i and the periodic rate by *r*, a common way of expressing the *NPV* is:

$$NPV = \sum_i \frac{CF_i}{(1+r)^i}$$

By simply using this measure as a decision foundation, the activity with the highest *NPV* is chosen. Naturally, uncertainties are attached both to the cash flow in a certain period and to the set of rates (which might vary between periods).

Basing decision on a single parameter like *NPV*, a separation between the investment and finance matters has been assumed. That is, the investment decision is separate from the financing decision. An effect of this is that only the resulting *NPV* is looked at without considering the (cumulative) cash flows in selected periods. The cumulative cash flows indicate the amount of money needed to finance an activity.

Comparing *NPV* to 0 (zero) means that the decision rule is that investments could be increased as long as the marginal return on investment is greater than the cost of capital (determined by the finance market).

Performing the *NPV* calculations, using a proper value for the periodic (discount) rate, *r*, is essential. This rate must reflect the cost of capital, that is an investor's rate of return when making an investment. The discount rate should then both cover a compensation for the time-value of money as well as a risk premium as seen by the investor.

The Capital Asset Pricing Model (CAPM) is a frequently applied approach for assessing the discount rate. This postulates that the cost of capital, *r*, equals the return on risk-free securities, ϕ, plus the market price of the risk (market premium), $(\mu - \phi)$, multiplied by the company's systematic risk, β. Hence,

$$r = \phi + (\mu - \phi) \bullet \beta,\ where\ \beta = \frac{\sigma_a}{\sigma}.$$

Here the systematic risk, β, is expressed as the ratio between the covariance of the activity, σ_a, and the variance of the market, σ. The risk-free return, ϕ, is the rate one should obtain for an investment without any risk and can be approximated with government securities.

Then, the market price of risk becomes the difference between the expected rate of return and the risk-free rate; $E[\mu] - \phi$.

As seen from above, the systematic risk is the correlation of the activity return with the market divided by the variance of the market return. This may be a challenging task, allowing for subjective decisions by selecting activities belonging to the "market" (i.e. a portfolio of comparable activities).

The CAPM approach is applied to estimate the cost of capital and thereby the discount rate to apply in the *NPV* analysis. Introducing uncertainties in the *NPV* approach may be done in several ways; One way is to use simulations for "generating" cash flows in each period. The result is a distribution for the *NPV* which then can be used to deduce observations with respect to whether or not to go for an investment. An example of such a measure is the probability of having an *NPV* below a certain threshold.

One of the drawbacks of the traditional *NPV* calculation is that the future cash flows are often modelled as deterministic. Moreover, once an activity is initiated, it can simply be "passively managed". In practise, however, the cash flows are uncertain and the activity may commonly be adjusted/changed by more active management. Often traditional *NPV* can be referred to as static *NPV* calculations.

In trying to capture the uncertainties, a set of scenarios can be devised. These scenarios could be identified in a number of ways; i) defining a set of uncertain factors and applying combinations of these to derive the scenarios, ii) defining a most likely outcome, together with a worst and a best outcome, iii) defining a set of scenarios depending on the outcome of (external) major factors.

The *NPV* can then be calculated for each of the scenarios. As described earlier, the scenarios help understand the uncertainties and derive the major factors to be observed and trigger actions. On the other hand, a number of drawbacks can be claimed, mainly due to i) the *NPV* calculation for each scenario is based on the same assumptions as the static *NPV* (deterministic cash flows and passive management), and ii) not capturing the option of jump between different scenarios during the course.

9.4 Decision Tree Analysis

The decision tree analysis is one approach for including the options revealed during the course of the activity. Setting up an event tree does this where the branches represent a cash flow outcome attached with the probability for that event to take place. The decision nodes are added to the tree where the management may choose to change the activity in order to respond to (external) factors or results of the activity. Such a method could for example be applied when analysing a complex sequential investment scheme where several decision points can be identified at discrete points of time, see Figure 27. Note the resemblance between decision tree and decision map in Figure 1. For a static *NPV* calculation, all uncertainty is presumably captured by the discount rate, the decision tree adds more understanding of the options during the activity's course and their probabilities. By modelling the investment as a decision tree, different actions in different scenarios or nodes in the tree can be introduced to incorporate the value of flexibility.

The tree is solved backwards from the leaf nodes and the beginning of the tree by discounting the relevant cash flows. The result is the value of the activity with flexibility as modelled in the tree.

This approach is intuitive and simple to comprehend, although it may have a number of limitations: i) the number of events may grow in a way such that analysing the tree is intractable, ii) the same discount rate is commonly used throughout the tree. Frequently, the risk differs at different nodes/branches inspiring for different discount rates. Commonly the discount rate applied is for an activity without flexibility.

9.5 Real Options

A net-present value (*NPV*) factor is usually derived for an activity and decisions made on this basis. A traditional *NPV* forces a decision to be made on the current set of information about the future. On the other hand, option valuation allows for additional flexibility of main decisions in the future, as more information will be available. This option of postponing a decision is captured in the option method that results in two additional types of values due to the simple fact that one will always want to postpone a final decision as long as possible. Firstly, one can earn the time value of money (e.g. interest). Secondly, as time passes until the decision has to be made, more information would be available such that a firmer foundation is achieved for making a decision.

Both arguments favour deferring a decision as long as possible. The traditional *NPV* criterion misses such an aspect. The real option methodology presumes the ability to postpone a decision and provides a way to quantify the value of deferring.

Using real option pricing, the value of an activity will always be greater than or equal to the value of a project using *NPV*. In case the identified flexibility by real option is unlikely to be used, the difference in pricing would be small. This is also likely to happen when the *NPV* is very high or very low (much negative). The greatest difference is likely to be seen when *NPV* is close to zero, hence referring to a project whose activation is questionable.

The higher the level of uncertainty, the higher the option value because flexibility allows for gains in the upside and minimise the downside potential. Often the total discounted operation

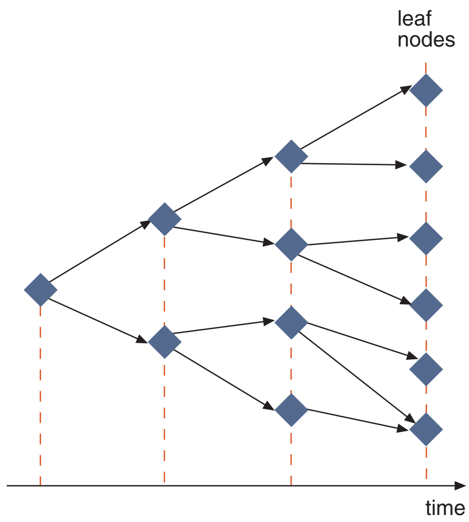


Figure 27 Decision tree analysis

[1] *Operating cash flow = revenue – all OAM, sales and other costs – variable follow investments (line cards, etc.)*

Investment option	Variable	Call option
Present value of a project's operating assets to be acquired	S	Stock price
Expenditure to acquire the project's assets	X	Exercise price
Length of time the decision may be deferred	T	Time to expiration
Time value of money	r_f	Risk-free rate of return
Riskiness of project assets	$\sigma\sqrt{T}$	Cumulative volatility

Table 4 Relating investment option and stock call option

cash flow[1] is modelled by a lognormal stochastic variable. The uncertainty is modelled by a volatility commonly used for financial call options.

Utilising real options, theory from financial analysis is applied to evaluate the value of physical or real assets. It is claimed that real options have been very useful in assisting top management of companies facing a significant managerial flexibility and amount of uncertainty.

There are two types of financial options: i) call options, and ii) put options. The former is a right to buy, while the latter is a right to sell (note: these are options and not obligations). Referring to an activity and the corresponding managerial flexibility, some relevant options are:

- Abandonment option (a put option): when the complete activity is stopped.
- Option to contract (a put option): when part of the activity may be stopped, outsourced, sold, etc.
- Option to expand (a call option): when the activity is enhanced.
- Option to defer: when a decision is postponed.

Combinations of options may also be identified. Two cases are:

- Compound option: an option is an option of the value of another option. For example, one may have the possibility to shrink or expand an activity, but the amount (e.g. how many parts) may be flexible. Another example is sequential option plan (e.g. for a phased activity plan) where an option may be a potential follow-on of another option.
- Switching options: reflecting the possibility of switch between two operation modes. Two examples are to: i) exit and re-enter by a modified activity plan, ii) change from delivering a certain result to another result. When the switching cost is greater than zero, situations may occur when one is still carrying on with the activity even though the result would be better if changes were incorporated. This is due to the high cost of changing the activity plan.

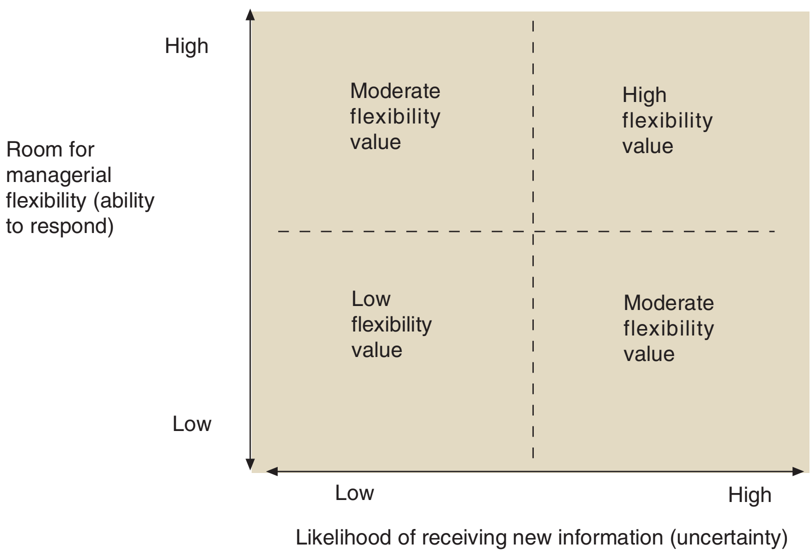
An important difference between real and financial options is that management can affect the value of the underlying risky assets as the actual project is under the management's control. Third parties control the financial options. This can be illustrated by mapping an investment question into a call options as shown in Table 4.

A number of observations can be made, see Figure 28:

- An increase in the present value of the project will increase the *NPV* (without flexibility) and therefore the option value will also increase.
- A higher investment cost will reduce *NPV* (without flexibility) and therefore reduce option value.
- A longer time to expiration allows learning more about the uncertainty and therefore will increase the option value.
- An increase in the risk-free rate of return will increase option value since it will increase the time value of money advantage in deferring the investment cost.
- In an environment with managerial flexibility an increase in uncertainty will increase option value.

In every case where the case value without flexibility is close to break even, the flexibility will have most relative value. Hence, the flexibility value is greatest when:

Figure 28 Estimating when managerial flexibility is greatest valued



- Great uncertainty about the future. Very likely to receive new information over time.

- Much room for managerial flexibility. Allows management to respond appropriately to this new information.

- *NPV* without flexibility near zero. If the activity is neither obviously good nor obviously bad, flexibility to change course is more likely to be used and is therefore more valuable.

In the financial world, the Black-Scholes formula is well-applied for valuing real options. This is an analytical solution to a differential equation describing the value of a European call option. The underlying risky asset is assumed to follow a geometric Brownian Motion with a Markov-Wiener stochastic process. When S is the value, the percent change is given by:

$$\frac{\delta S}{S} = \mu \cdot \delta t + \sigma \cdot \varepsilon \cdot \sqrt{\delta t}$$

where

μ is a drift term or growth parameter that increases at a factor of time steps δt.

δ is the volatility parameter, growing at a rate of the square root of time.

ε is simulated, usually following a normal distribution with a mean of zero and variance of one.

The first term is the deterministic part and the second term is the stochastic part.

A number of limitations on this formula are: there is only one source of uncertainty, no compound options are included, the underlying stochastic process is assumed to be known, the variance of return is constant through time, the underlying risky asset follows a Geometric Brownian Motion with a Markov-Wiener stochastic process.

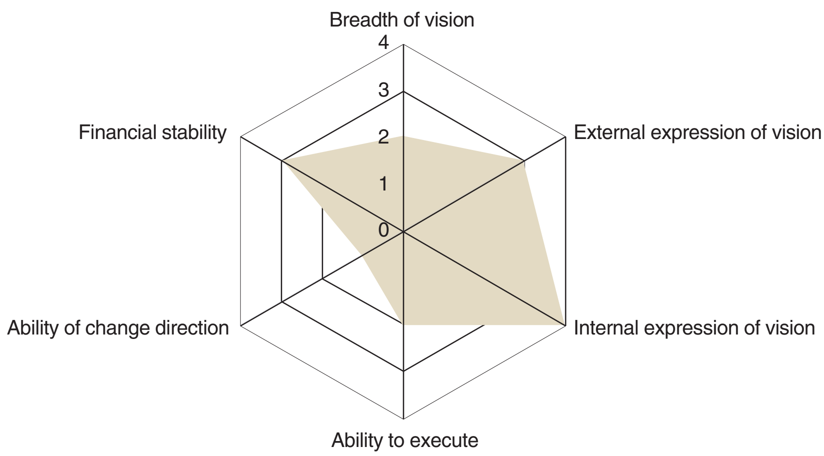
One way of modelling real options is to apply binomial lattices. Market-replicating portfolios and risk-neutral approach could for instance be used when calculating the values of the option sets. The basic idea is to represent the evolving uncertainty of the value of a risky asset by a binominal tree. The risk itself may or may not increase with time, but uncertainty increases with time. This can be considered as an uncertainty cone (hence growing as time passes). In the same way as the Black-Scholes formula this relies on a Geometric Brownian Motion following a Markov-Wiener process. As for any tree, time is discretised, and hence it may become quite demanding to compute every combination. As a limit, the value of an option calculated according to the binomial lattice approaches the time continuous solution of Black-Scholes as the number of time-steps in the binomial tree gets larger.

The calculations are started from the leaf nodes of the tree (similar to Figure 27) where the question of whether to exercise the option or not is a trivial one (being the end-points). The calculations are run backwards to the beginning of the tree, choosing the best decision of whether to exercise or not at each branch/node of the tree. At each branch/ node the market-replicating portfolios or the risk-neutral approach can be applied, both being equivalent to each other. The former refers to finding an equivalent combination of risky and risk-free assets, while the latter refers to adjusting the cash flows in the *NPV* calculations.

Naturally, one may raise the question of how to find an equivalent portfolio when referring to an activity "never-seen-before" for a certain company. On the one hand, it can be claimed that these are all models used as background when making the actual decisions. On the other hand, the static *NPV* of an activity could be used as a best-guess on the unbiased estimate of the market value of the activity. Considering the value including flexibility, one could consider this as placing one part of the money on the activity and another part in bonds.

The binomial event tree describes the evolving uncertainty of the underlying risky asset and the stochastic process is based on a single volatility. Monte Carlo simulation is commonly used to produce the volatility for the return of activity. This is however based on the assumption that the uncertainty is resolved continuously over time. There are often different causes for uncertainties, such as market and technology. These may well be resolved differently with time; an example being that technological uncertainties decrease with time while market uncertainties increase with time.

Figure 29 Potential categorisation of vendor's strength



Real Options – Referring to Stocks

One model for stock behaviour is a so-called geometric Brownian motion. The time discrete version is expressed as:

$$\frac{\Delta S(t)}{S(t)} = r_f \Delta t + \sigma \varepsilon \sqrt{\Delta t}$$

where:

$S(t)$ – stock price at time t

$\Delta S(t)$ – change in stock price during a short time interval, Δt

r_f – drift rate (risk-free rate of return)

σ – volatility

ε – random number drawn from a standard normal distribution (~N(0,1)).

Now it can be shown that $S(t)$ is log normally distributed with mean value given as

$$\mu_t = \ln(S(0)) + \left(r_f - \frac{\sigma^2}{2}\right) t$$

and standard deviation of $\sigma_t = \sigma\sqrt{t}$.

The measure under consideration, here the total discounted value of the operating cash flow of a project, T, is estimated at $S(0)$ with the current information. Up to decision time, T, the management receives information of relevant value and the measure value will therefore move up or down with accumulated volatility $\sigma\sqrt{t}$.

The project investment is only incurred if $S(T) > X'' = X + (1 + r_D)^2 V$, where X is the initial investment at time T and V is the NPV of the second phase of the project if the uncertain action is not carried out. r_D is the discount rate.

The NPV at time T is found as:

$$NPV = E\left[\max(S(T) - X,\ (1 + r_D)^2 V)\right]$$

$$= \int_{X''}^{\infty} (S(T) - X) p(S(T)) dS(T) + \int_{0}^{X''} (1 + r_D)^2 V p(S(T)) dS(T)$$

where

$$p(S(T)) = \frac{1}{\sigma_T \sqrt{2\pi S(T)}} e^{\frac{-(\ln(S(T)) - \mu_T)^2}{2\sigma_T^2}}$$

After some reordering and variable substitution (e.g. $w = \ln(S(t)) \rightarrow S(T) = e^w$, $dS(t) = e^w dw$), one gets

$NPV = e^{-r_f T} (S\,\mathrm{N}(d_1) e^{r_f T} - X\,\mathrm{N}(d_2)) + V (1 - \mathrm{N}(d_2))$

where

$$d_1 = \frac{\ln\left(\frac{S}{X''}\right) + \left(r_f + \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} \quad \text{and} \quad d_2 = \frac{\ln\left(\frac{S}{X''}\right) + \left(r_f - \frac{\sigma^2}{2}\right) T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}.$$

N(.) is the cumulative standard normal distribution (~N(0,1)).

9.6 Stochastic Optimisation

Stochastic optimisation is an operational research technique for handling uncertainty. This is applied in order to optimise simulation models by defining a stochastic model and accompanying decision variables. Iterations are carried out between drawing input parameters from selected distributions and optimising the decision variables for each set of draws. In some sense this is similar to solving the task of finding the best path in a decision tree.

9.7 Evaluating Vendors

One element in the risk assessment is evaluating the situation of the current vendors. Both technical and financial criteria have to be considered.

Having an assessment of the key vendors for an operator is also central. Several criteria could be derived, of which some are (from [Heav03]):

- Breadth of vision
- External expression of vision
- Internal expression of vision

- Ability to execute
- Ability to change direction
- Financial stability

This inspires for illustrative factor diagrams as shown in Figure 29. However, it is important to be aware that the sequence of factors influences the area of the diagram.

10 Overall Results

Regarding the overall objective of network strategy studies, more than one target state may very well be described within each study. A natural justification for this is that a future time frame is commonly attached with uncertainty, leaving it unlikely that every factor influencing the solutions will be known. Hence, instead of looking for the ultimate solution, a decision tree approach could be strived for. That is, paths of migration are put together to choose which branch to follow if the tree is attached with a set of conditions. These conditions may be related to time and events. On a more abstract level every branching would actually be event-related, although some indication of timing will be of interest. This is schematically illustrated in Figure 30. The network naming has been chosen simply for illustration. Moreover, more than two branches might appear from one state. Following a line from a network without any merging or splitting into branches indicates an upgrade of network capabilities.

Following a branch in the tree both the consequences and the risks must be assessed. Consequences reflect costs, revenue side, product portfolio, organisation and so on. Here, the total portfolio has to be taken into account, possibly leading to investments in a certain system resulting in overall reduced operational expenses because a less efficient system could be phased out.

It is essential to have captured the relevant risk factors when choosing the right implementation track for core network migration. In other words it is not sufficient for an implementation track to be technically feasible and having the smallest cost among the various implementation options, the option must also have a sufficiently low risk to be considered for actual implementation. Risk factors can be grouped into technical, financial and business/strategic. The first refers to factors such as whether the technical solutions are actually able to deliver the services as promised, compatibilities between versions/vendors, etc. Financial issues come from the income and the expense side, where none of these are fixed in the period. Business and strategic issues refer to relations with regulatory bodies, organisation, communication with customers/competitors, and so forth.

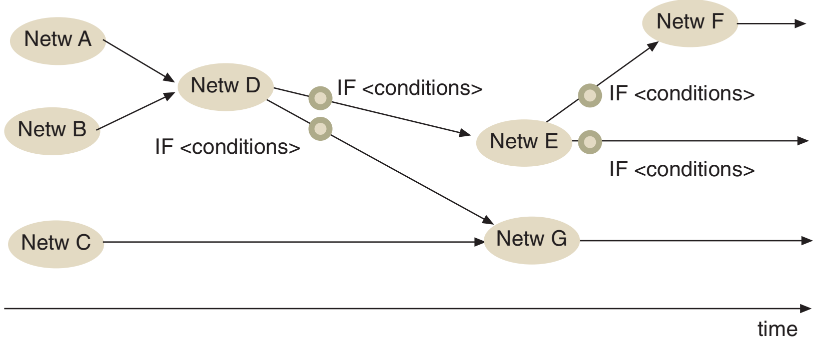


Figure 30 Illustration of network portfolio migration states with decision points

Production means

	Netw A	Netw B	Netw C	…..
Product z	V		V	
Product x		V	V	
Product w		V		
….				

Year 200y

Figure 31 Relating products and production means for each time period

Naturally, any modification of an existing operating network implies certain risks. In particular there are risk factors related to upgrading nodes related to cost, functionality and capacity. This also applies to any work of integrating networks, and other steps taken in case an additional aggregator function is to be introduced (as assumed for some of the cases/tracks). On the other hand, there may also be risks involved when no changes are carried out. This could come because the system portfolio may gradually become less efficient than what competitors manage and too slow to deploy new services.

As mentioned in the beginning it is essential that the network strategy elaborated is related to the current situation and thereby possibly leading to a change of the decisions to be made in the shorter term.

The products to be supported have to be related to the network portfolio illustrated in Figure 30. This may be thought of as a 'product – production means' matrix, as shown in Figure 31. Here the main product groups are given along one axis and the production means on the other axis. Such a matrix must be defined for each period/year looked at. In a period a product may be provided in a number of ways, partly competing and partly complementing. Doing the exercise of

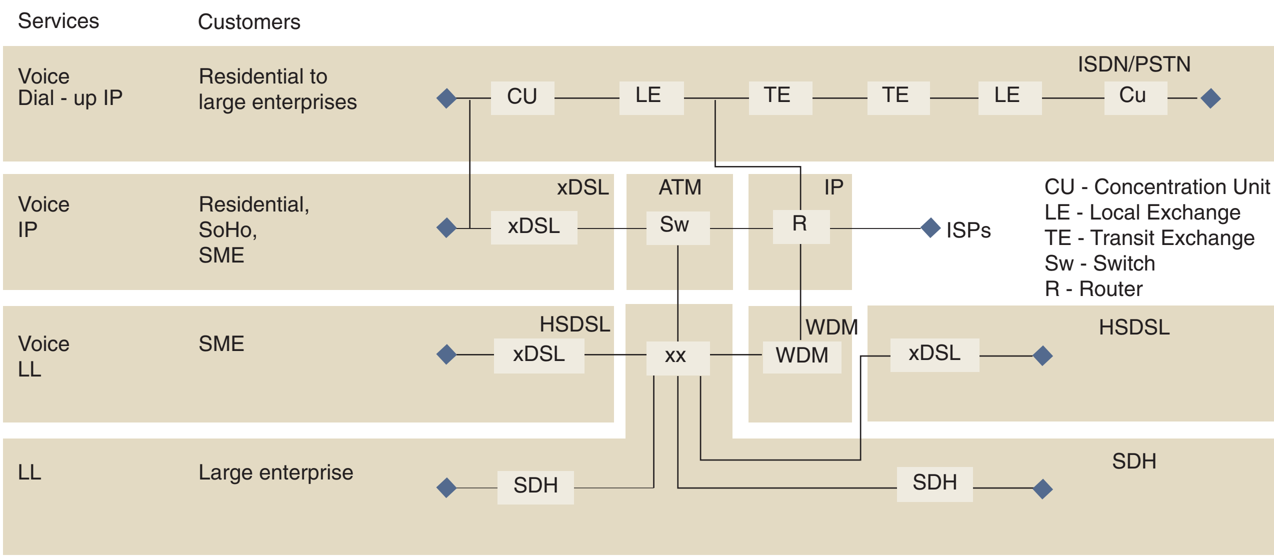


Figure 32 Example of relating services/customer segments to production means (Note: not all relevant systems are included, e.g. the mobile systems)

relating products to production means will reveal further areas of potential gains.

To some extent products to be supported have been described earlier. A few basic trends have also been outlined earlier. Regarding the demand patterns, most sources indicate a growth in most issues, leading to rather questionable aggregated demands. However, trends showing main growth areas within mobile, IP and xDLS are repeatedly observed.

Defining how to efficiently support the different products belongs to the network portfolio management. A basic challenge is to relate the services and market segments. An example of how this may be carried out is depicted in Figure 32.

11 Concluding Remarks

A network strategy is needed for every sound network operation. The strategy must also be related to decisions and actions in near-time – hence, the strategy must be made operational. A main goal of having a strategy is to be prepared for chances that can be revealed during the course of events. That is, the strategy is likely to assist when detecting business opportunities. The total network portfolio must be included, also seeing synergies between the different systems in the shorter and longer terms.

In elaborating the strategy a number of methods can be applied, including scenarios, cost/benefit calculations and risk assessment. A description of various aspects is outlined in this article.

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