HELSINKI UNIVERSITY OF TECHNOLOGY
Networking Laboratory

Network investments

S-38.3041 Operator Business

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Lecture outline

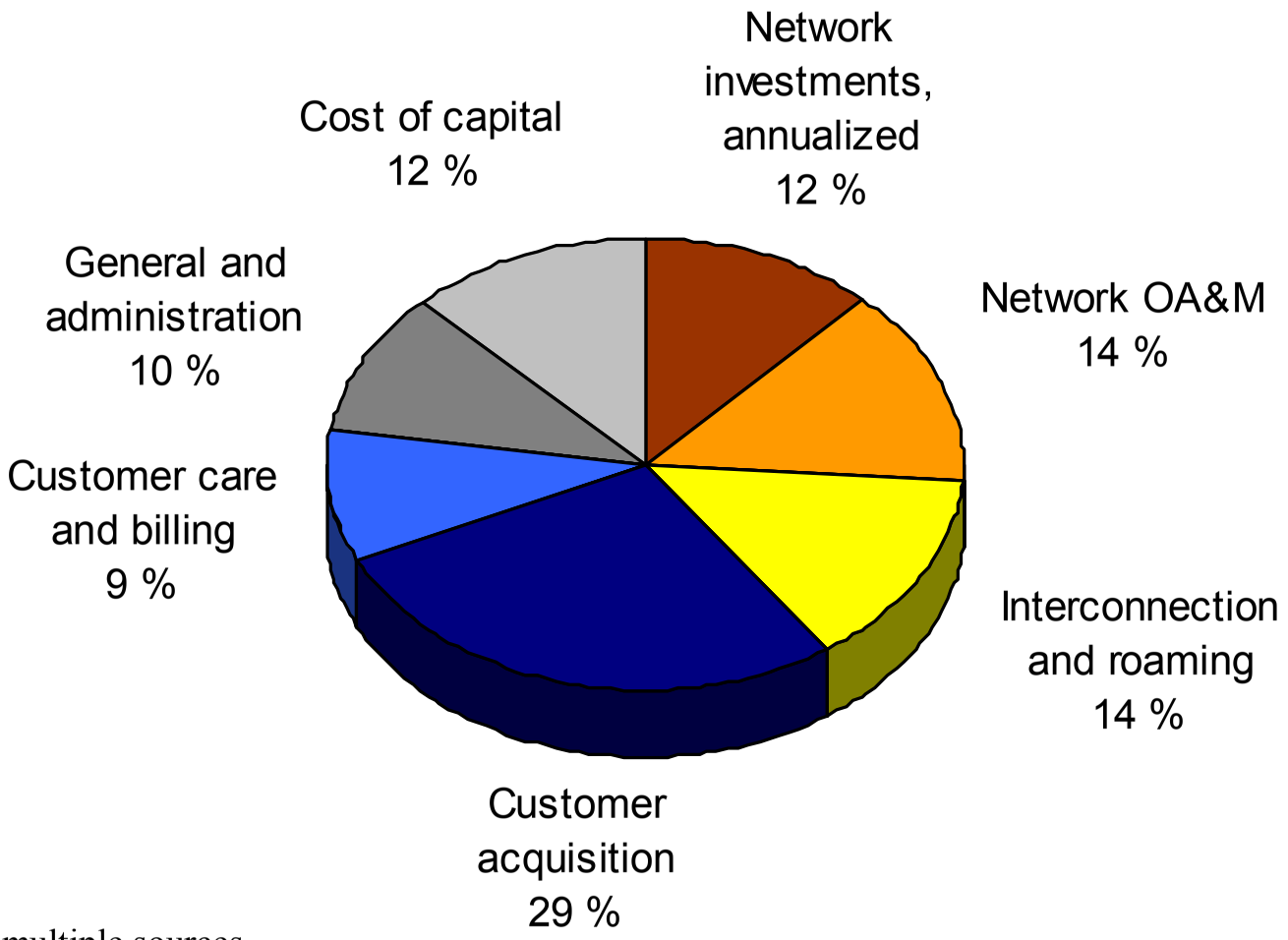
- Introduction
- Discounted Cash Flow (DCF) analysis, basics
  - NPV, IRR
- Techno-economic models and tools
  - Inputs, logic, and outputs
  - Revenue modelling
  - CAPEX modelling
  - OPEX modelling
- Example case: Fixed WiMAX

Introduction

- Extensive capital investments required in the telecommunications industry
  - Fiber / copper cables, active elements, spectrum licenses
- Expanding set of both complementary and competitive access technologies
  - ADSL, ADSL2+, VDSL, FTTH, Cable modems, WiMAX…
  - GPRS, EDGE, WCDMA, HSDPA, WLAN, WiMAX, DVB-H, Flash-OFDM, …
  - ”Technology portfolio” must be optimized
- Systematic analysis required to compare investment possibilities

Introduction

Cost structure of mobile operators



Average over multiple sources

Operator investments
Big picture

- Types of large investments:
  - Material (e.g. network coverage & capacity,
  - Immaterial (e.g. brand marketing, spectrum license)
- Types of funding:
  - Risk-averse >> financial loans (e.g. banks, equipment suppliers)
  - Risk-seeking >> equity investments (e.g. governments, private equity)
- Analysis methods:
  - Calculation of incremental business case for service
  - Revenue modelling: accessible market, market share, ARPU
  - Cost modelling: Traffic demand >> required capacity >> cost
  - Simulation with multiple scenarios (what-if and sensitivity analyses)

Operator investments

Relative characteristics of selected examples

	Cellular licence	Cellular coverage	Cellular capacity	New service
Decision mode	One-step	One-step	Incremental	Optional
Investment size	High or low	High	Medium	Low
CAPEX (%)	High (& low)	High	Medium	Low
OPEX (%)	Low	High	Low	Medium
Payback time	Long	Long	Short	Short

- Services are based on other services (e.g. MMS over GPRS)
- Cross-elasticity of services >> high common costs >> calculation problems

Discounted Cash Flow analysis

Basic concepts

- Cash flow, CF
  - Amount of cash flowing to/from a company / project during a time period.
- Payback period
  - Amount of time required before the cumulative cash flows turns positive
- Discount rate, r
  - Reflects the opportunity cost of capital
- Discounted cash flow, DCF
  - Value of a cash flow adjusted for the time value of money
- Net present value, NPV
  - Sum of all DCFs during a study period
- Internal rate of return, IRR
  - Discount rate that gives a NPV of zero

$$DCF_t = \frac{CF_t}{(1+r)^t}$$

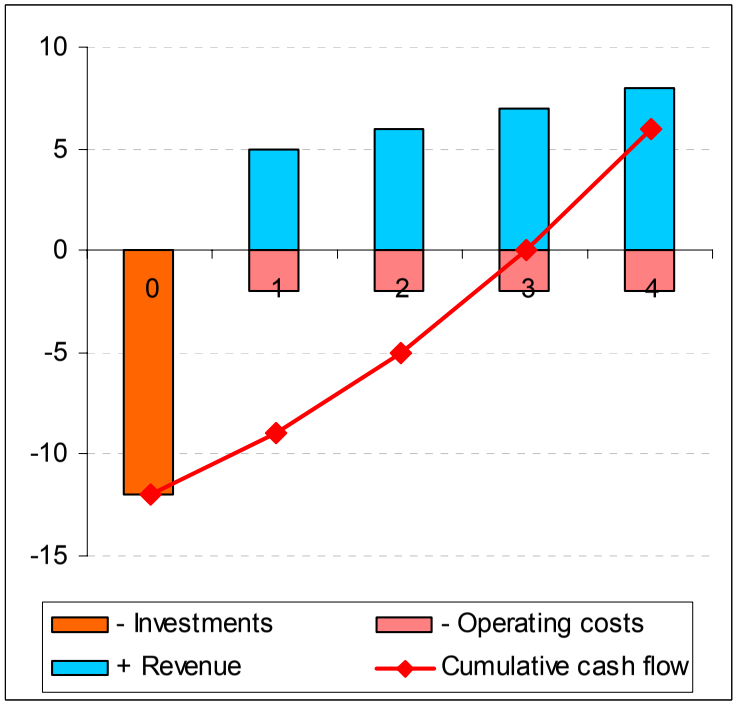
$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}$$

DCF analysis

Simple example

- Consider a project yielding the following cash flows:

Year	0	1	2	3	4
+ Revenue	0	5	6	7	8
- OPEX	0	-2	-2	-2	-2
- CAPEX	-12	0	0	0	0
= Cash flow	-12	3	4	5	6
Cumulative cash flow	-12	-9	-5	0	6



- As seen, the payback period is 3 years
- With different discount rates, we get the following DCFs and NPVs:

Discount rate	15 %				
Discounted cash flow	-12,00	2,61	3,02	3,29	3,43
Net present value	0,351				

Discount rate	20 %				
Discounted cash flow	-12,00	2,50	2,78	2,89	2,89
Net present value	-0,935				

- Iteration gives us the IRR:

Discount rate = IRR	16,3 %				
Discounted cash flow	-12,00	2,58	2,96	3,18	3,28
Net present value	0,000				

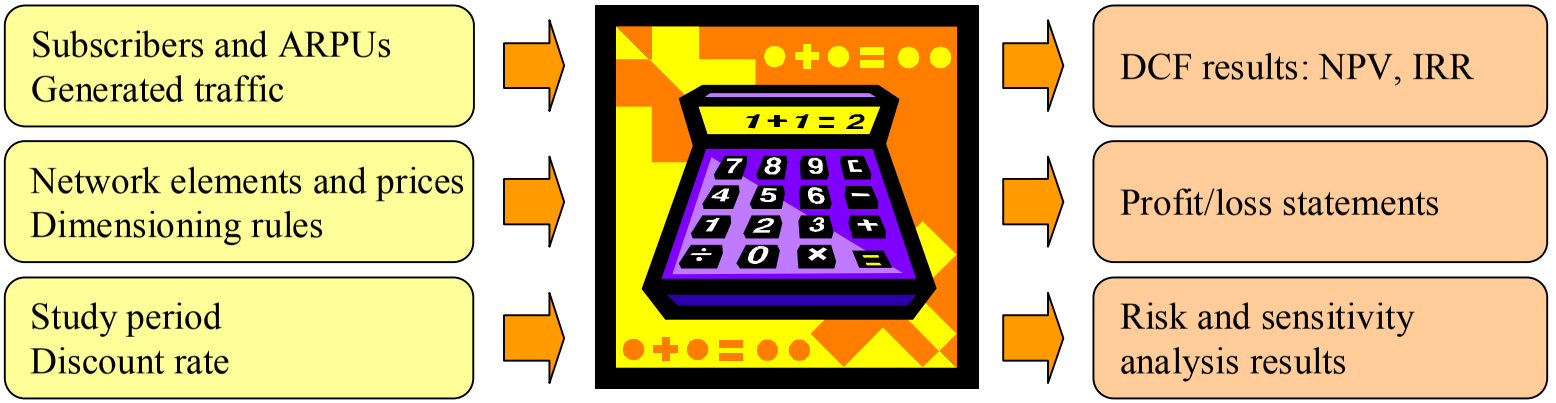
Techno-economic models and tools

Logic and inputs

- Profit = Revenue – Cost
  = (Subscribers * ARPU) – (CAPEX + OPEX)
- Revenue side modelling:
  - Service penetration
  - Market share evolution
  - ARPU evolution
  - Revenue sharing models
- Cost side modelling:
  - CAPEX
    - Network dimensioning, cost evolution
  - OPEX
    - OAM costs: fixed, per service, per subscriber

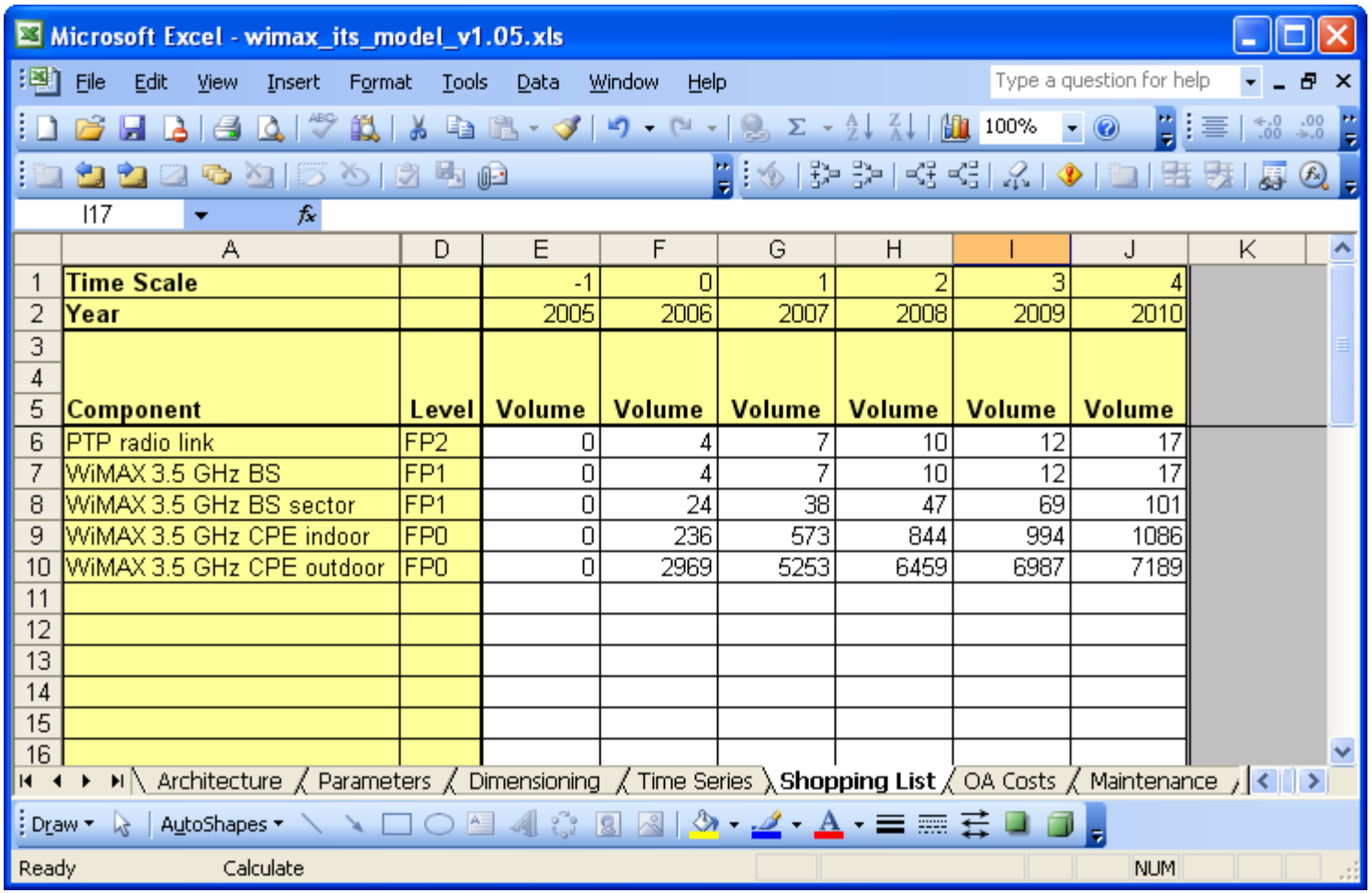
TONIC/ECOSYS tool

Example of a techno-economic tool



- Excel-based spreadsheet application
- Integrates basic DCF methods and analysis logic to an user-friendly tool
- Automates many straight-forward calculations
  - Time savings, less errors, repeatibility
- Considerable aid in sensitivity and risk analyses
- Majority of the work still has to be done outside the tool

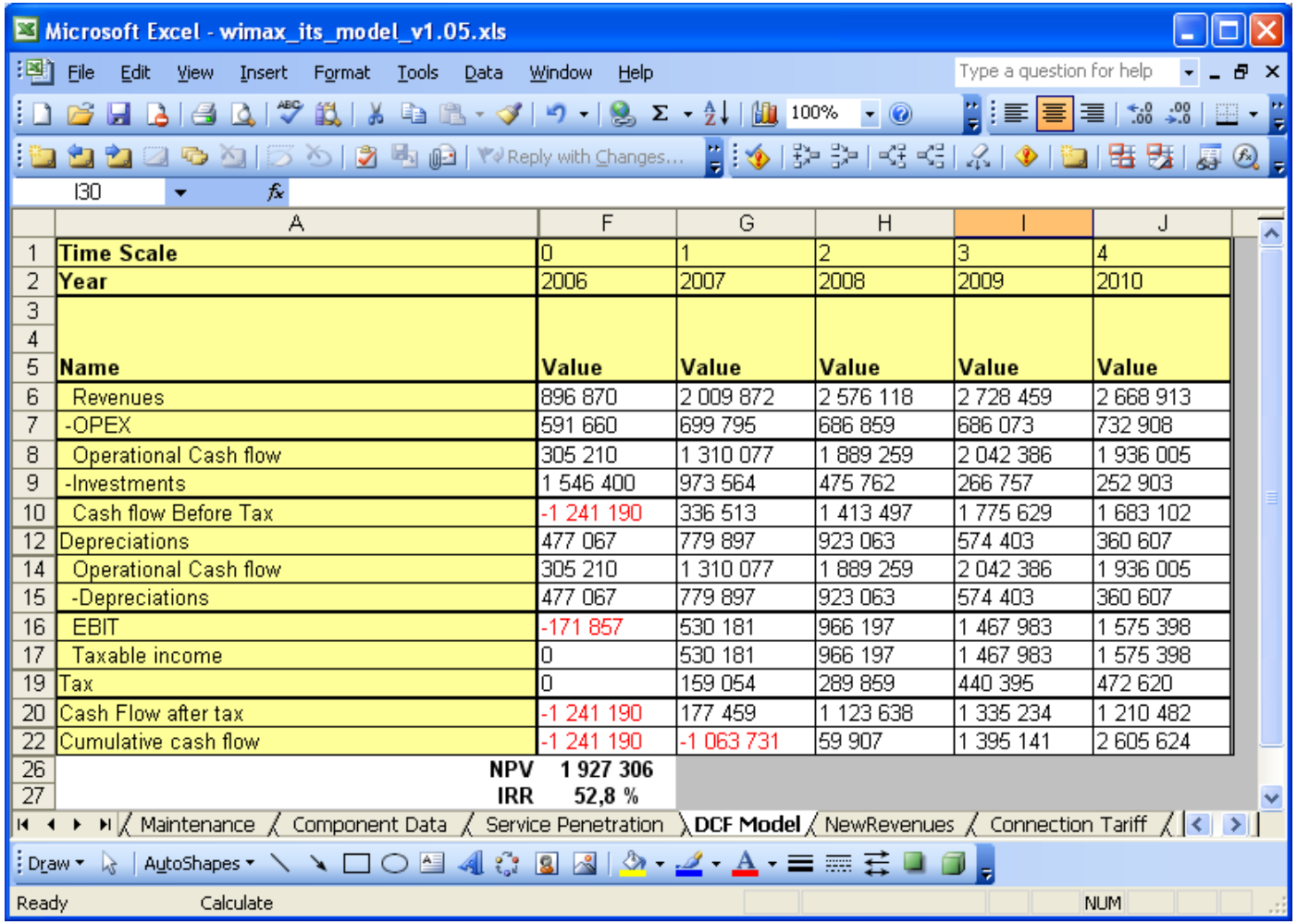
TONIC screenshot: Shopping List



	A	D	E	F	G	H	I	J	K
1	**Time Scale**		-1	0	1	2	3	4	
2	**Year**		2005	2006	2007	2008	2009	2010	
3									
4									
5	**Component**	**Level**	**Volume**	**Volume**	**Volume**	**Volume**	**Volume**	**Volume**	
6	PTP radio link	FP2	0	4	7	10	12	17	
7	WiMAX 3.5 GHz BS	FP1	0	4	7	10	12	17	
8	WiMAX 3.5 GHz BS sector	FP1	0	24	38	47	69	101	
9	WiMAX 3.5 GHz CPE indoor	FP0	0	236	573	844	994	1086	
10	WiMAX 3.5 GHz CPE outdoor	FP0	0	2969	5253	6459	6987	7189	
11									
12									
13									
14									
15									
16									

TONIC screenshot: Results

Mixed DCF analysis and Profit/Loss statement



Microsoft Excel - wimax_its_model_v1.05.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

100%

Reply with Changes...

I30

	A	F	G	H	I	J
1	**Time Scale**	0	1	2	3	4
2	**Year**	2006	2007	2008	2009	2010
3						
4						
5	**Name**	**Value**	**Value**	**Value**	**Value**	**Value**
6	Revenues	896 870	2 009 872	2 576 118	2 728 459	2 668 913
7	-OPEX	591 660	699 795	686 859	686 073	732 908
8	Operational Cash flow	305 210	1 310 077	1 889 259	2 042 386	1 936 005
9	-Investments	1 546 400	973 564	475 762	266 757	252 903
10	Cash flow Before Tax	-1 241 190	336 513	1 413 497	1 775 629	1 683 102
12	Depreciations	477 067	779 897	923 063	574 403	360 607
14	Operational Cash flow	305 210	1 310 077	1 889 259	2 042 386	1 936 005
15	-Depreciations	477 067	779 897	923 063	574 403	360 607
16	EBIT	-171 857	530 181	966 197	1 467 983	1 575 398
17	Taxable income	0	530 181	966 197	1 467 983	1 575 398
19	Tax	0	159 054	289 859	440 395	472 620
20	Cash Flow after tax	-1 241 190	177 459	1 123 638	1 335 234	1 210 482
22	Cumulative cash flow	-1 241 190	-1 063 731	59 907	1 395 141	2 605 624
26	**NPV**	**1 927 306**				
27	**IRR**	**52,8 %**				

Maintenance | Component Data | Service Penetration | DCF Model | NewRevenues | Connection Tariff

Draw AutoShapes

Ready Calculate NUM

Revenue modelling

- Revenue = Penetration * Market share * ARPU
  - Service penetration forecasts
    - E.g. trend extrapolation, analogies
  - Achievable market shares
    - Number/size of competitors, regulation, strategy (mass/niche)
  - Tariff/ARPU evolution
    - Difficult to forecast, linked to e.g. competition, regulation, targeted market segment
    - >> Use of alternative tariff scenarios and sensitivity analyses
- Different revenue types: e.g. retail service revenues, interconnection, roaming

CAPEX and OPEX

- Two different views/uses:
- In accounting
  - CAPEX is *capitalized*, i.e. added to an asset account and depreciated over many years
  - OPEX is *expensed*, having an effect on the current year only
- In cash flow analysis
  - All costs are attached to the actual time period during which they occur, no depreciations
  - >> CAPEX and OPEX are treated in the same way

Profit/loss statement:

Year	**0**	**1**	**2**	**3**	**4**
+ Revenue	0	5	6	7	8
- OPEX	0	-2	-2	-2	-2
= EBITDA	0	3	4	5	6
- Depreciation	0	-3	-3	-3	-3
= EBIT	0	0	1	2	3
- Interests and taxes	0	0	-0,3	-0,6	-0,9
= Profit / loss	0	0	0,7	1,4	2,1

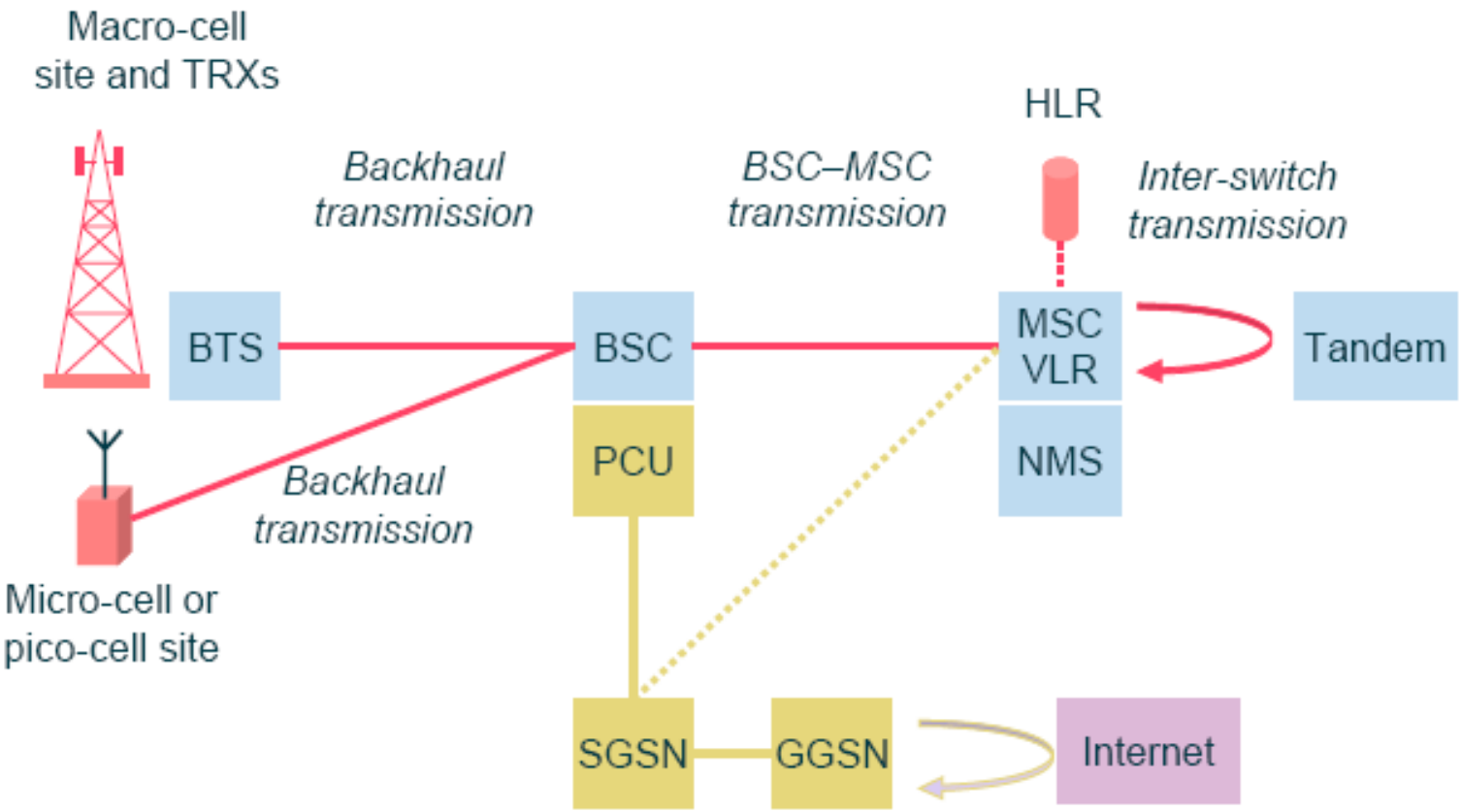
Cash flow analysis:

Year	**0**	**1**	**2**	**3**	**4**
+ Revenue	0	5	6	7	8
- Operating costs	0	-2	-2	-2	-2
- Investments	-12	0	0	0	0
= Cash flow	-12	3	4	5	6
Cumulative cash flow	-12	-9	-5	0	6

CAPEX modelling

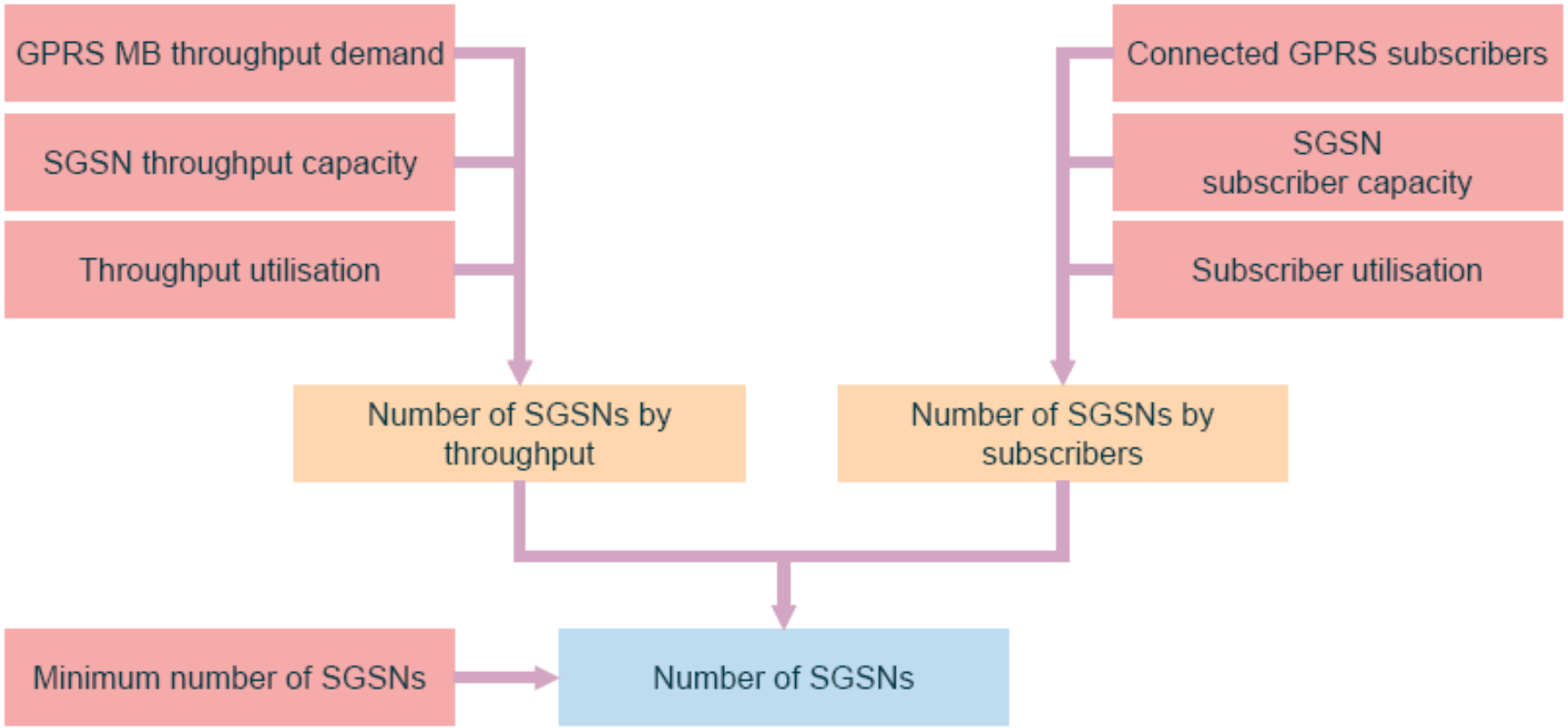
- Network engineering and dimensioning skills required!
- Network architecture
  - Hierarchy of nodes and links
- Network element characteristics
  - Capacity / coverage
  - Price evolution
- Traffic demands
  - Busy hour traffic demand
- >> Required investments per year

Example: Network architecture and cost elements



Source: Swedish National Post and Telecom Agency, 2003

Example: GPRS SGSN calculation



Source: Swedish National Post and Telecom Agency, 2003

OPEX modelling

One possible classification

- Network-related OPEX
  - Operations, administration, maintenance & provisioning (OAM&P)
  - Driven by number of network elements
- Sales & marketing
  - Depends on chosen strategy and market conditions
  - Affected by e.g. churn, handset subsidies, advertising campaigns
- Billing and customer care
  - Drivers: Number of subscribers, quality of customer care
- Interconnection and roaming
  - Paid to other operators
  - Drivers: Minutes of use
- General & Administration
  - As a percentage of e.g. revenues

OPEX modelling - example

1 Network related elements	Example formula
Network operations and administration	x% of cumulative investments
Network maintenance	x% of cumulative investments
Equipment installations	x% of equipment cost
Site rentals	x € per m2 x € per network element
2 Sales and marketing related elements	
Sales and marketing	x € per new customer
Handset subsidies	x € per new customer
3 Customer service related elements	
Customer care	x € per customer per year
Charging and billing	x € per customer per year
4 Interconnection and roaming	
Interconnection	x € per outgoing minute
Roaming	x € per minute
5 Other	
General & Administration	x% of revenues

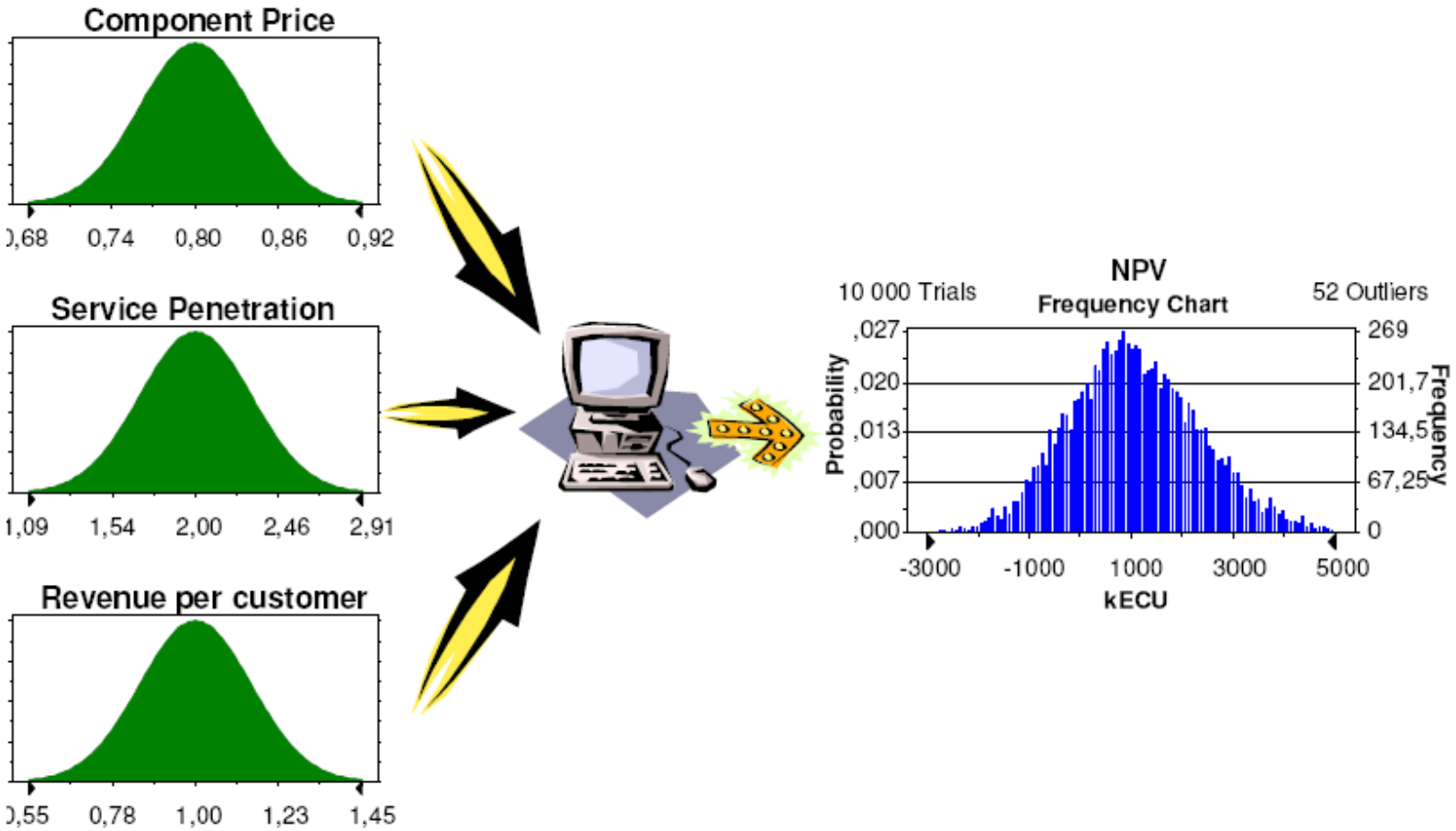
Risk and sensitivity analyses

Tackling uncertainty

- Most of the inputs to the models are uncertain
  - Service tariffs >> Competition, regulation
  - Service penetration and usage>> Alternatives, fashion
  - Element prices >> Mass market adoption
- Uncertainty can be coped with different means
  - Sensitivity analysis:
    - considers the effects of changes in key assumptions only one at a time
  - Scenario analysis:
    - many or all of the variables are changed simultaneously, enabling different what-if and worst/best case scenarios to be analyzed
  - Simulation analysis:
    - probability distributions specified for the variables, Monte Carlo simulation used to generate thousands of different scenarios

Risk and sensitivity analyses

Example



Techno-economic case studies

- Technology-oriented
  - WLAN / WiMAX
    - Feasibility as substitute and/or complement to 3G
    - Fixed (vs. ADSL), Mobile (vs. GSM/3G)
  - Broadband / Fiber-to-the-x scenarios
- Service-oriented
  - Feasibility of Mobile TV
  - Voice over X
    - GSM vs. WCDMA CS vs. VoIP vs. PoC vs. VoWLAN...
- Business model -oriented
  - Feasibility of MVNOs
    - MVNO strategies and evolution paths: SP > ... > Full MVNO
    - Differentiation vs. cost leader strategies

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Example case study

WiMAX for fixed broadband access

Case background

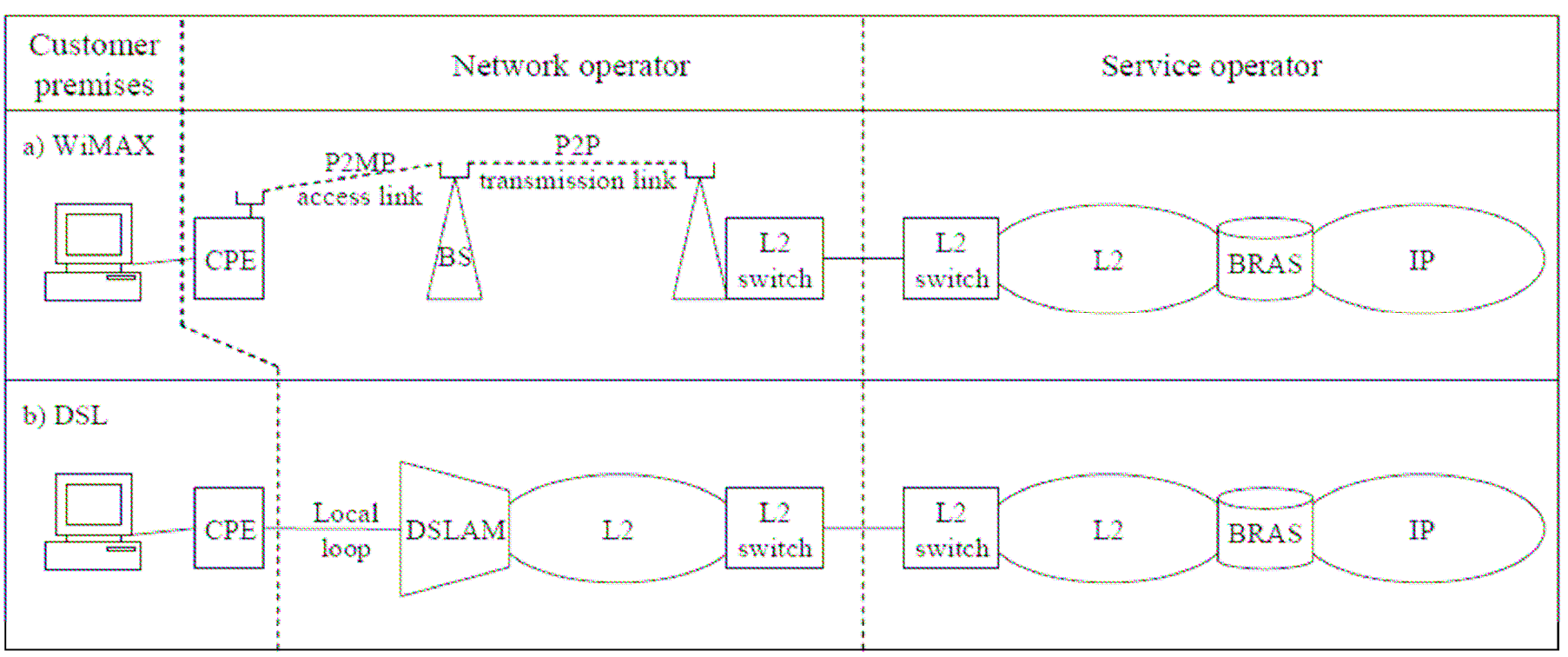
- Broadband market is experiencing strong growth across Europe
- DSL has become the most popular broadband access method:
  - >60% in OECD, about 80% in Europe
  - Cable modem systems follow, other technologies in minor role
- Competition in the broadband market is intensifying
  - Service-based competition
    - new entrant operators utilize the incumbent's existing network infrastructure and offer DSL services by means of fully unbundled lines, shared access lines, bitstream access, or resale
  - Facilities-based competition
    - new entrants build and operate their own access network infrastructure, based on e.g. cable modem systems
    - WiMAX-based fixed wireless access networks proposed as another alternative

WiMAX hype

- ”WiMAX will provide
  - data rates of 70 Mbps and
  - cell ranges of 50 km
  - in non-line-of-sight link conditions,
  - and with price levels similar to WLANs”…
  - … NOT!
- Tradeoffs between capacity, coverage, and cost have to be understood

WiMAX network architecture

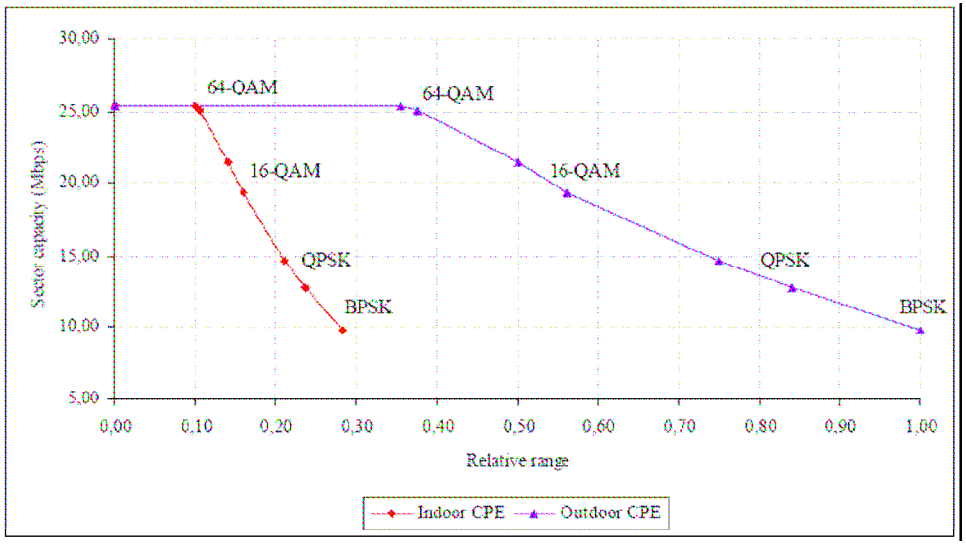
- CPEs, base stations + sectors, and transmission links
  - CPE price ~ 300-500 euros >> subsidies required



WiMAX capacity and coverage

- Adaptive modulation utilized to maximize cell capacity
  - More robust and less efficient modulations (BPSK, QPSK) used at the cell edge
- Average sector capacity is a function of sector range
- Empirical path loss models used to determine the maximum cell range
  - SUI models, ECC-33

Sector capacity (channel BW = 7 MHz)



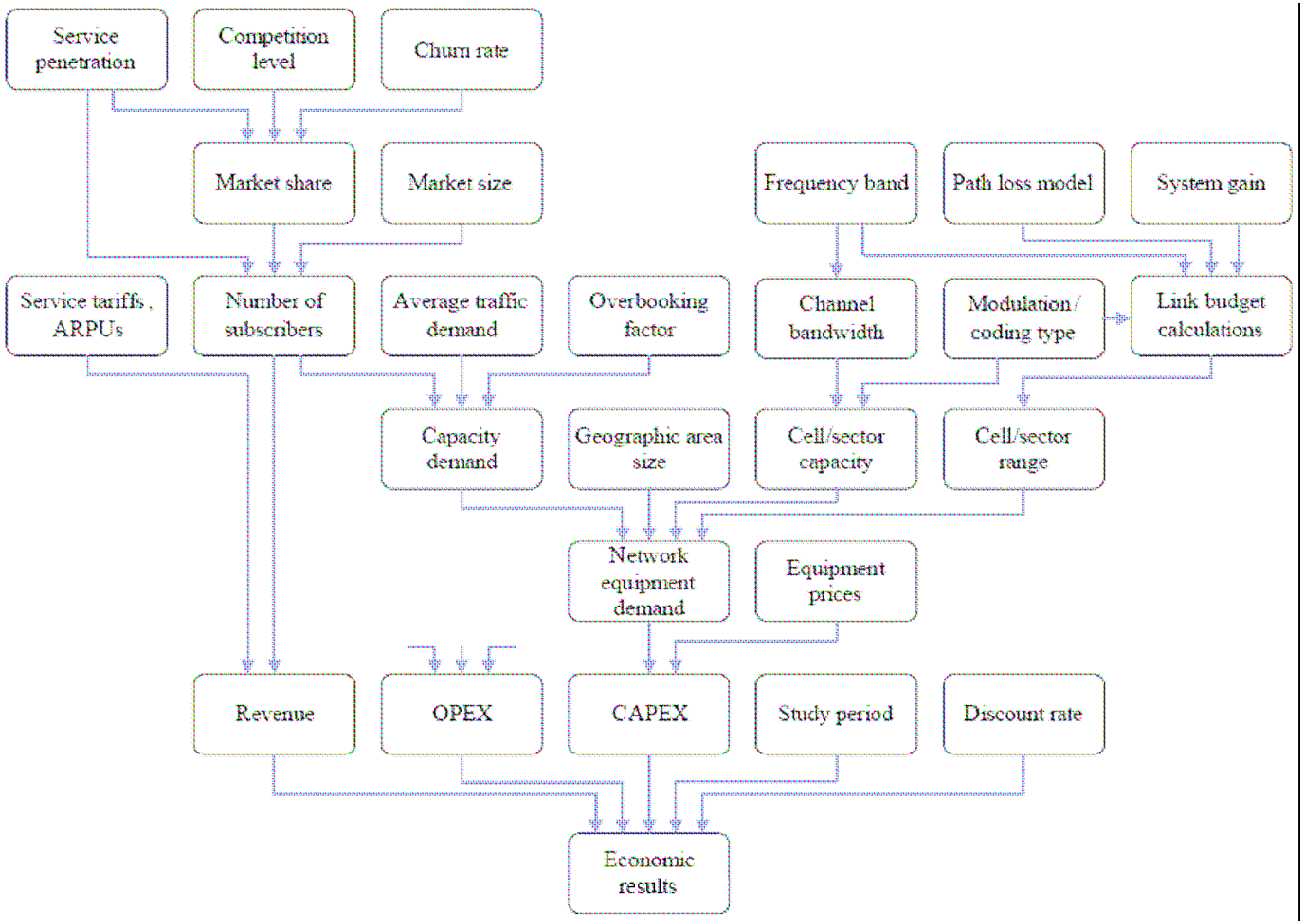
Sector range (for 3.5 GHz NLOS systems)

Area type	Urban	Suburban	Rural
Cell range, NLOS, indoor CPE	0.56 km	0.73 km	-
Cell range, NLOS, outdoor CPE	2.0 km	2.6 km	-
Cell range, obstructed LOS, outdoor CPE	-	-	10.0 km

Cost assumptions

Cost component	Price in 2006	Price evolution
Spectrum license fee (e.g. 8 x 7 MHz)	25.000 €	-
WiMAX 3.5 GHz BS	10.000 €	-15% per year
WiMAX 3.5 GHz BS sector	7.000 €	-15% per year
BS installation cost	5.000 € per BS + $500 per sector	-
BS site rental	1.800 € per BS per year + 1.200 € per sector per year	-
Transmission link equipment (P2P radio link + port in core switch)	25.000 € per BS	-10% per year
P2P radio link site rental	2.400 € per BS per year	-
WiMAX 3.5 GHz indoor CPE	300 €	-20% per year
WiMAX 3.5 GHz outdoor CPE	400 €	-20% per year
Outdoor CPE installation cost	100 € per installation	-
Network equipment administration and maintenance costs	20% of cumulative investments	-

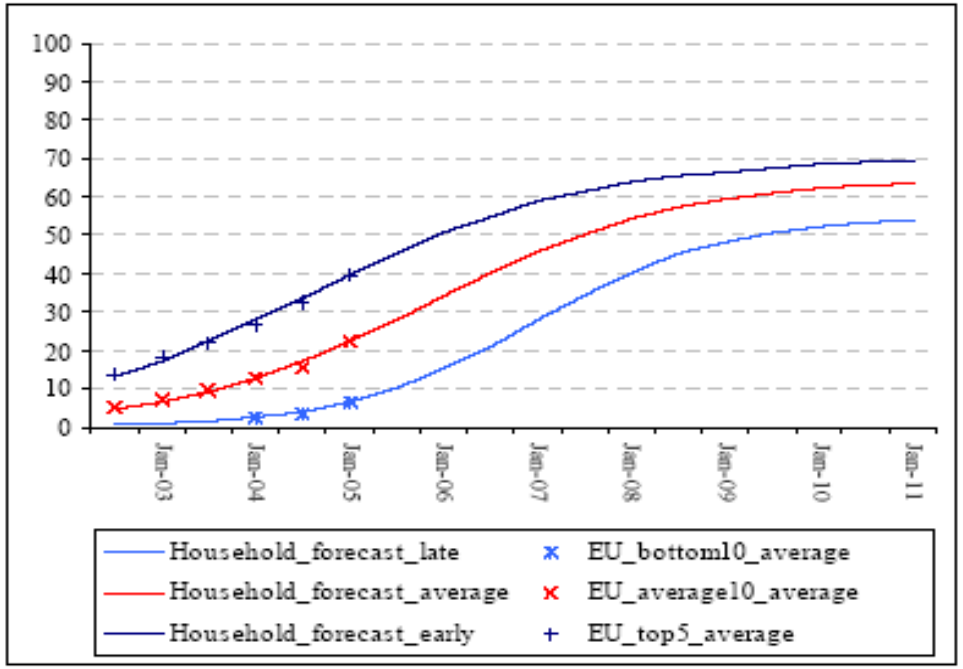
Techno-economic model



Market / service assumptions

- Three country groups
  - Early, Average, Late
- Three area types
  - Urban, Suburban, Rural
- Service data rates:
  - HH: 1Mbps, +20%/year
  - SME: 2Mbps, +20%/year
  - Overbooking factors 20 and 4
- Retail ARPUs:
  - 30 Eur (HH), 200 Eur (SME)
  - -15% per year
- Wholesale (bitstream) tariffs:
  - 70% of retail ARPU

Penetration forecasts for country groups:



Area type characteristics:

Area type	Urban	Suburban	Rural
Area size (km2)	10 … 50	100 … 500	2500 … 10000
Household density (1/km2)	5000 … 1000	500 … 100	20 … 5
Business density (1/km2)	500 … 100	100 … 20	2 … 0.5
Competition level	2	1.5 *	1 *
DSL availability	100%	95%	75%

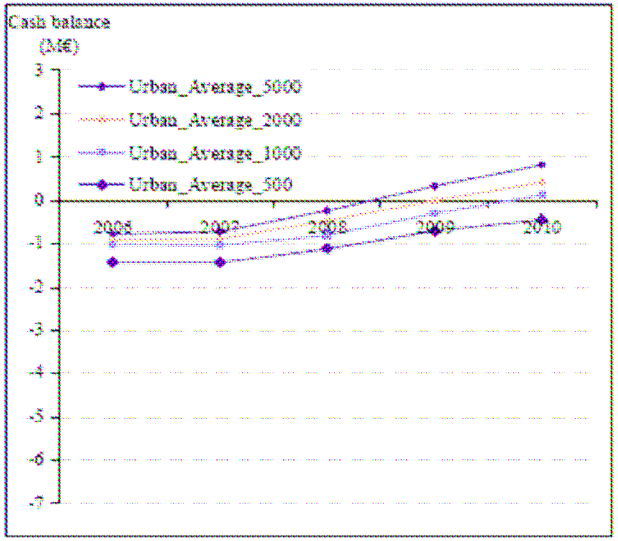
* only in areas with DSL coverage, no competition in residual markets

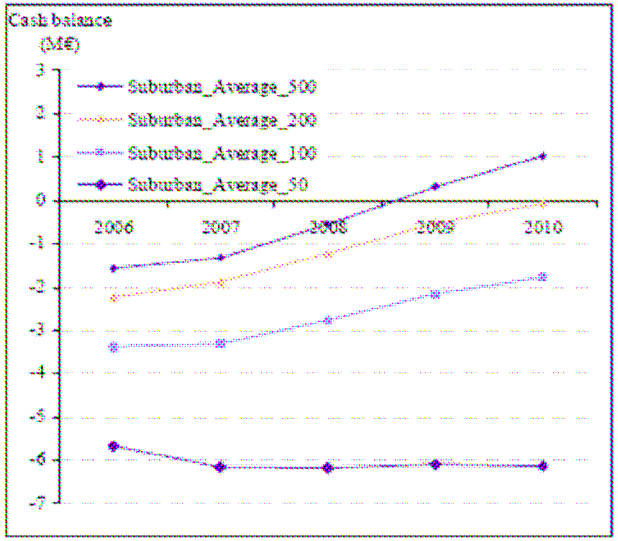
Economic results

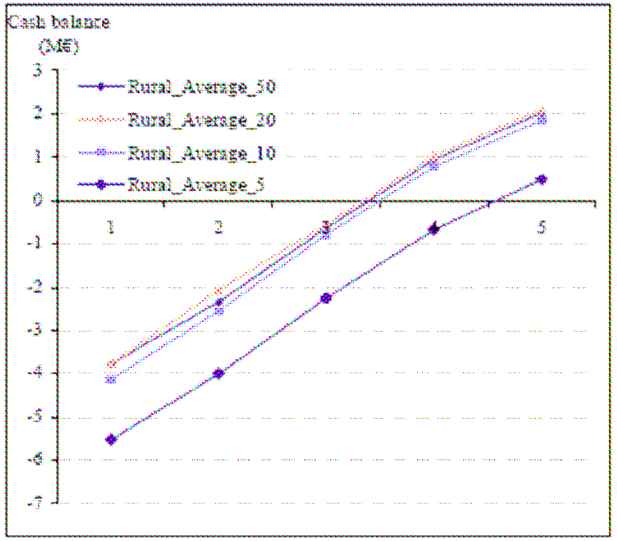
- Urban areas show moderate profitability
- Only the areas with very high HH density are clearly profitable
- All-indoor deployments have poor profitability

- Suburban areas show generally low profitability
- Good availability of alternatives
- Coverage-limited deployments

- Rural areas show good results on HH densities above 10/km2
- Large market share gives rise to high revenues outweighing the initial investments







Case	NPV (M€)	IRR
Urban_Average_5000	0,534	31,3 %
Urban_Average_2000	0,216	17,8 %
Urban_Average_1000	-0,058	8,1 %
Urban_Average_500	-0,562	-5,5 %

Case	NPV (M€)	IRR
Suburban_Average_500	0,575	23,0 %
Suburban_Average_200	-0,353	3,4 %
Suburban_Average_100	-2,062	-19,1 %
Suburban_Average_50	-6,056	-59,5 %

Case	NPV (M€)	IRR
Rural_Average_50	1,291	24,1 %
Rural_Average_20	1,406	25,7 %
Rural_Average_10	1,072	21,1 %
Rural_Average_5	-0,495	5,9 %

WiMAX case conclusions

- WiMAX deployments can be profitable in dense urban areas as well as in rural areas with limited availability of other alternatives
  - Low profitability in urban and suburban areas with medium population densities and high availability of other access network alternatives
- In some area types the networks are coverage-limited, whereas in others the sector/cell capacity defines the required investments
  - Coverage-limited network deployments are generally less profitable
- Performance of WiMAX systems appears to be suitable for the broadband traffic demands of today
  - Emergence of services requiring higher data rates will be problematic
- Most critical success factors for WiMAX networks are the CPE price and broadband tariff levels
  - All-indoor CPE deployments are generally non-profitable due to excessively high initial investments

Lecture summary

- Techno-economic modeling are useful in analyzing emerging technologies
  - Feasibility studies, opportunity/threat analyses
  - Combined use of e.g. trend analysis, quantitative modeling, scenarios, and basic capital budgeting methods
- The models cannot predict the future
  - Analysis of alternative future scenarios still possible
  - Sensitivity analyses give insight to the dynamics of the models and reveal critical success factors

References

- [1] Porter, A., 2006. Presentation at the course: Analysis of Emerging Technologies. Espoo, 28 March 2006.
- [2] Vanston, L.K. & Hodges R.L., 2004. ”Technology forecasting for telecommunications”. Telektronikk 4.2004. http://www.tfi.com/pubs/w/pdf/telektronikk_peer.pdf.
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- [4] Smura, T., 2005. Competitive potential of WiMAX in the broadband access market: a techno-economic analysis, in ITS 16th Biennial Conference, Porto, Portugal, 4-6 September, 2005. http://www.netlab.tkk.fi/~tsmura/