IDLab
INTERNET & DATA LAB

Techno-economic analysis of reliable ICT networks and services

Sofie Verbrugge

Invited talk DRCN2017
Munich, Germany, March 9th 2017

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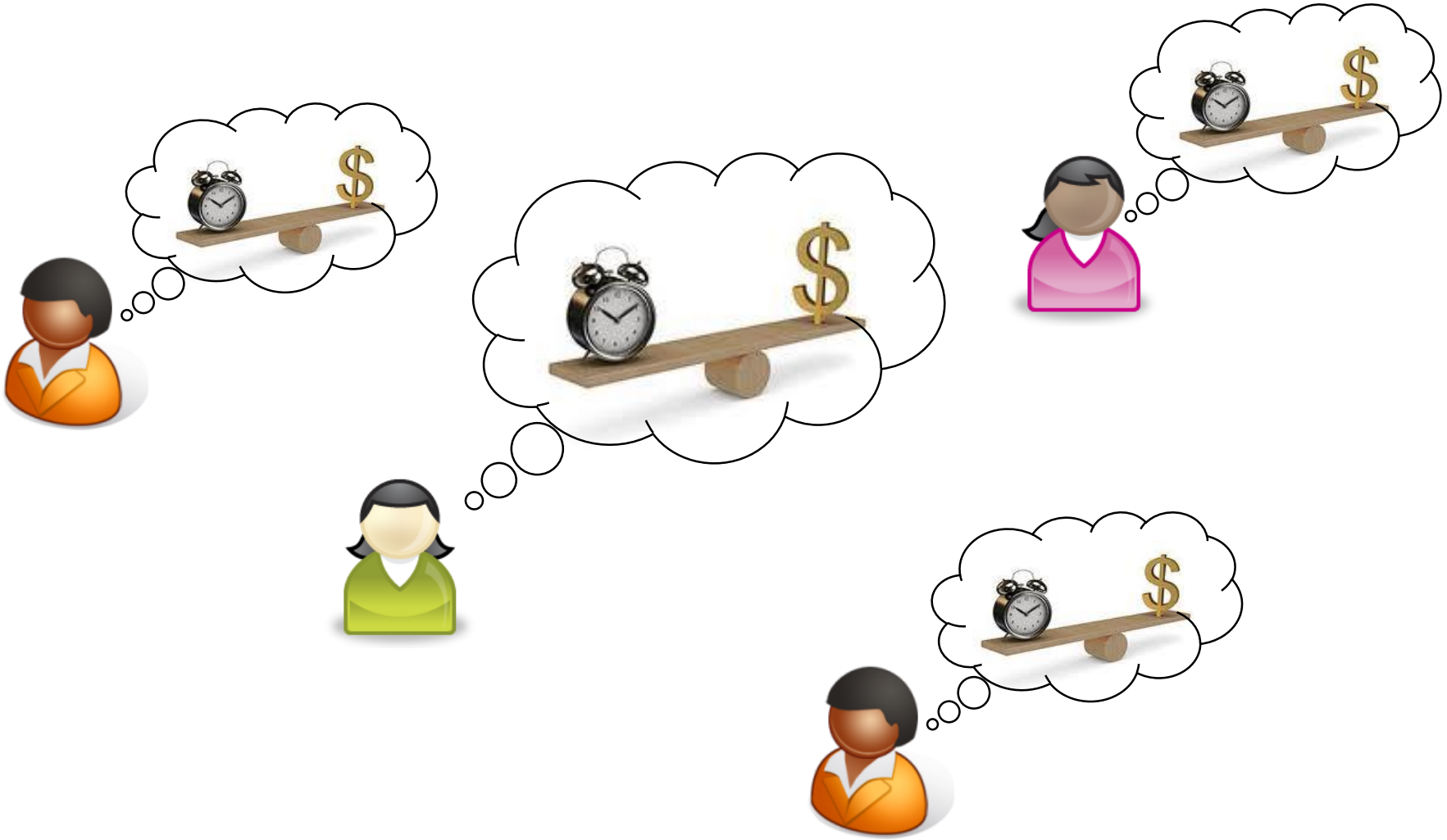
imec

Techno-economic analysis

supports investment decisions

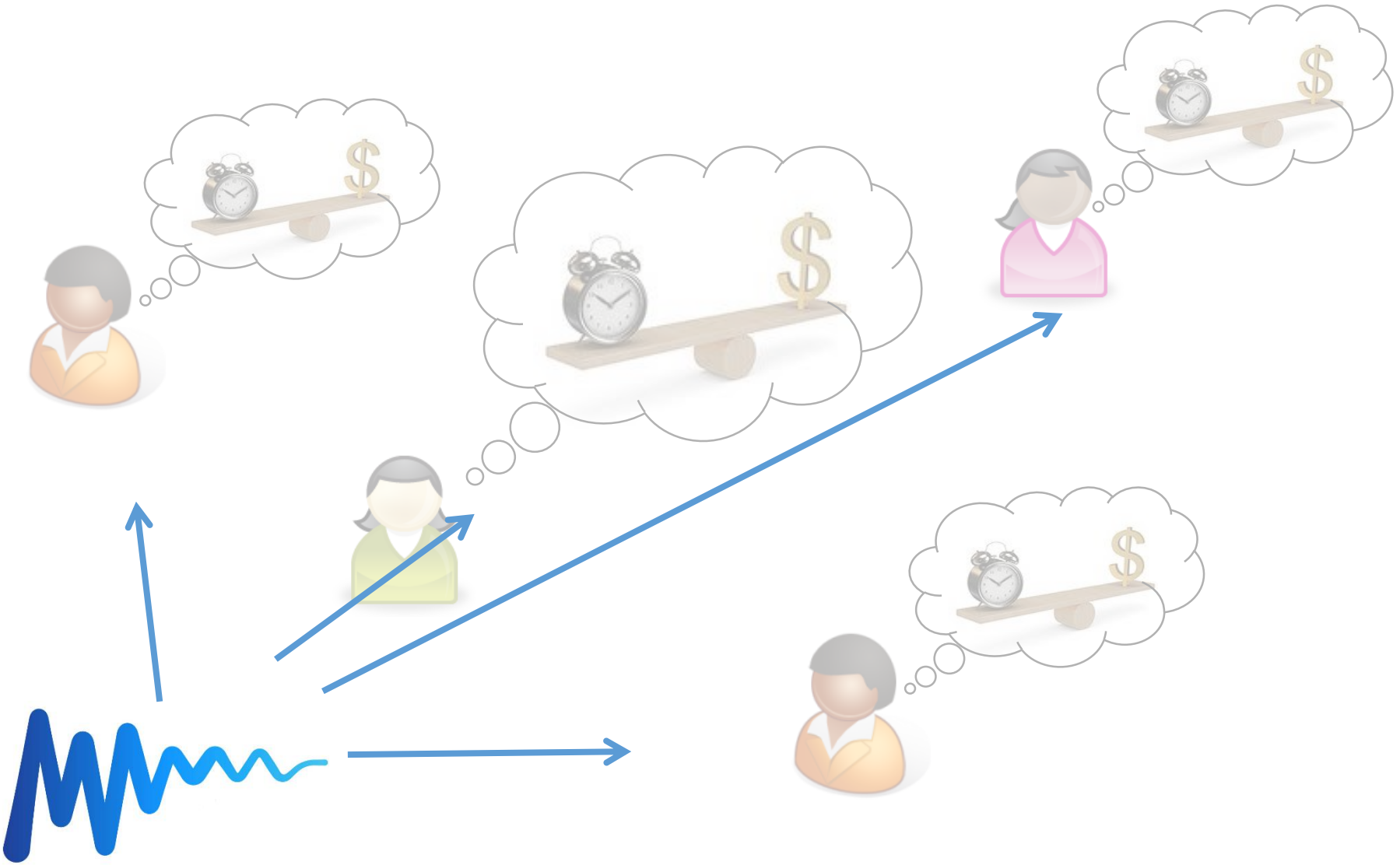
Techno-economic analysis

is always done in a multi-actor context



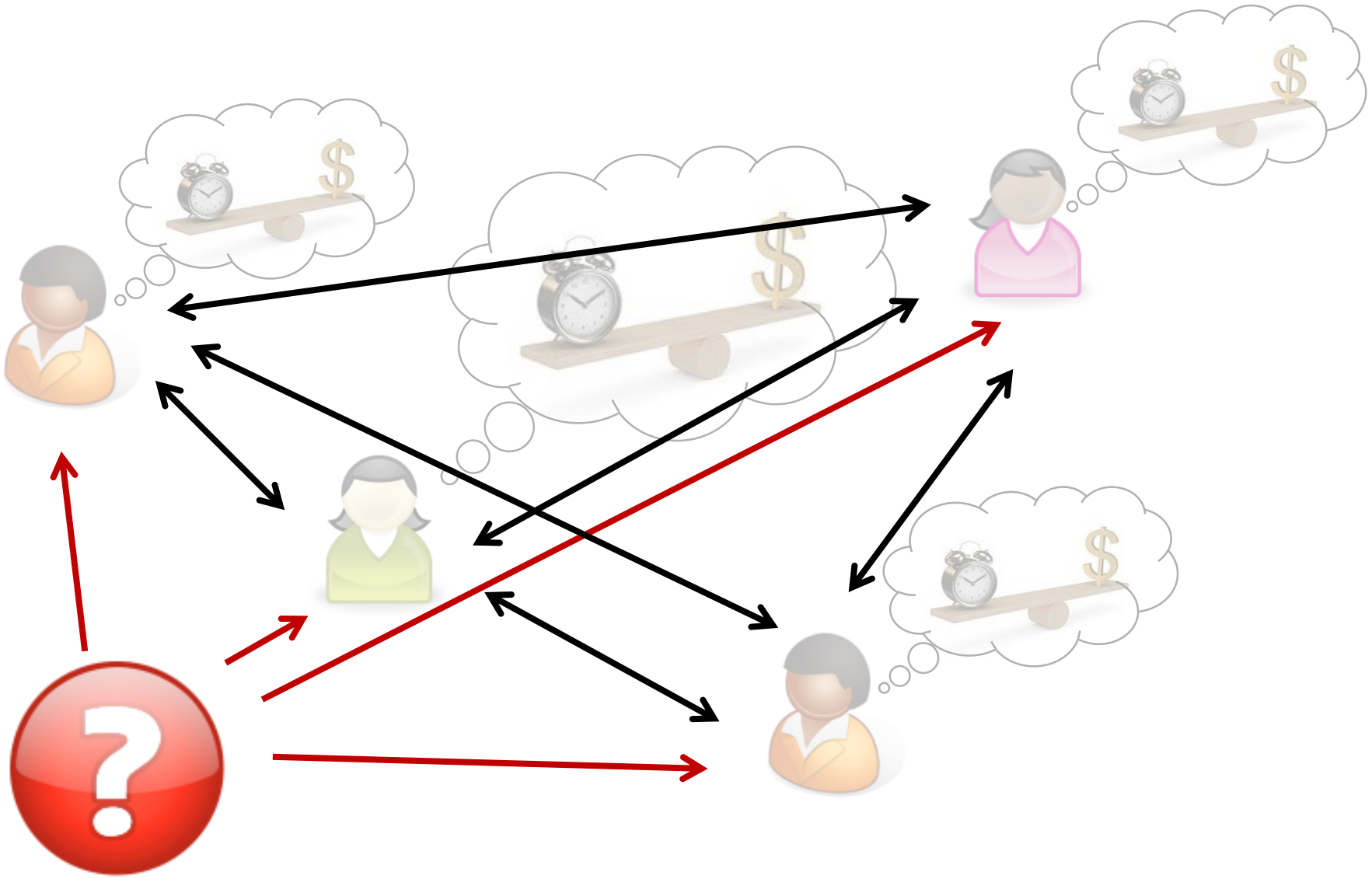
Techno-economics analysis

deals with expected market and customer dynamics



Techno-economics analysis

takes the impact of uncertain changes into account



Techno-economics analysis

needs to adapt to boundary conditions

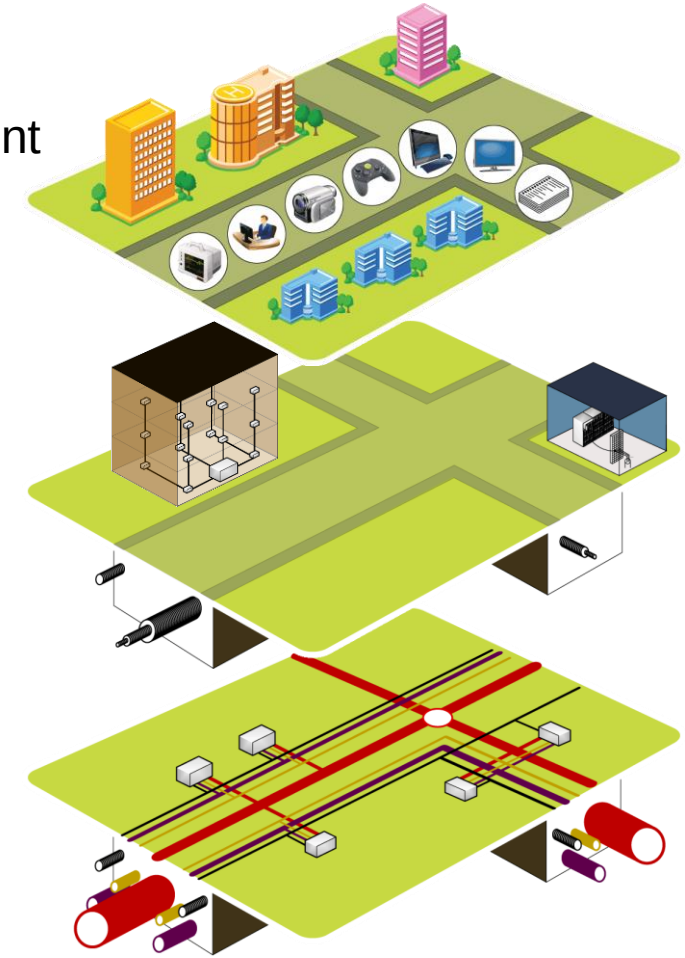
Investment decision based on innovation

can be situated on different layers in the network stack

Service deployment and operations

Network deployment

Infrastructure deployment

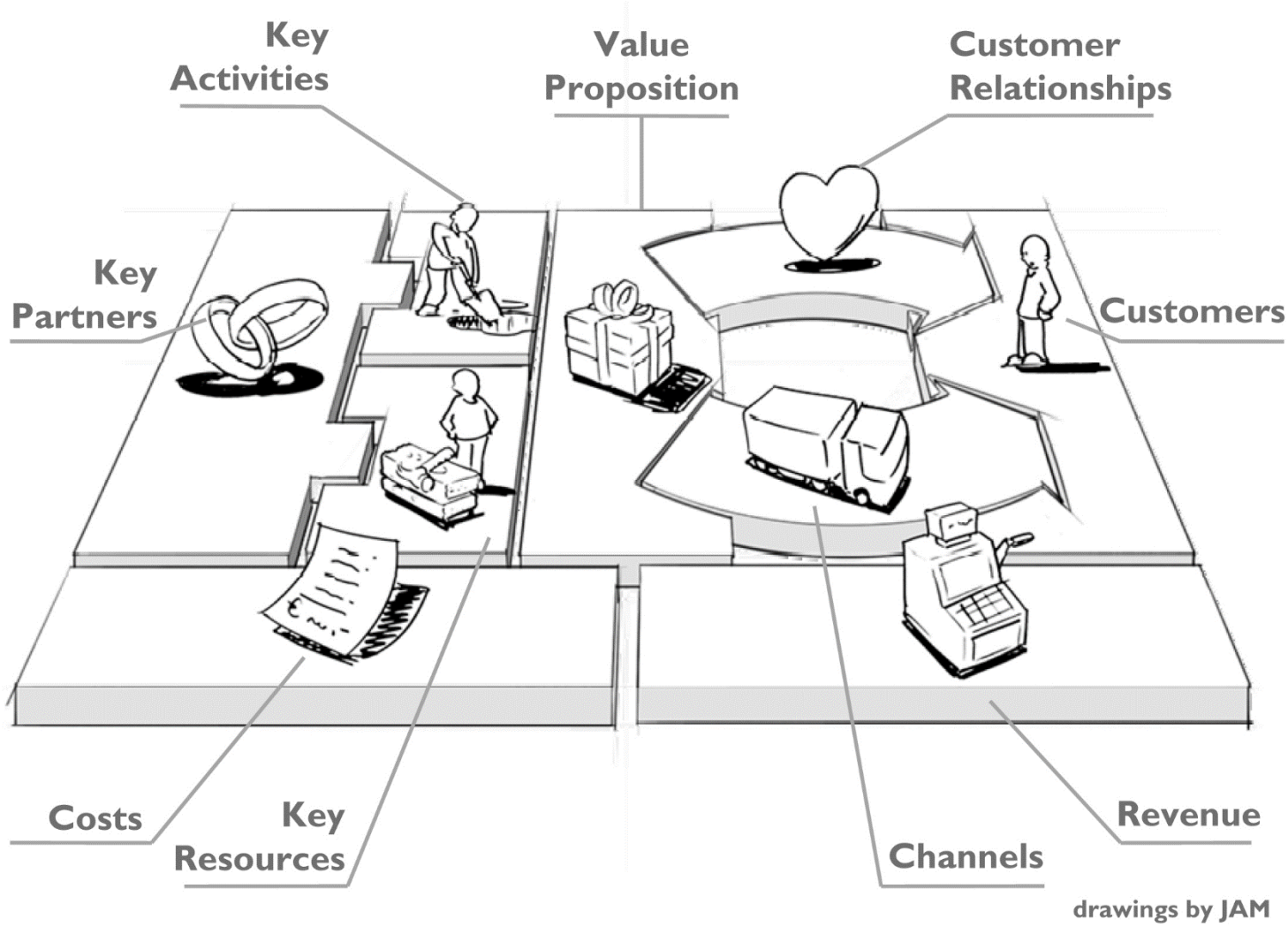


Outline

- What is techno-economic analysis?

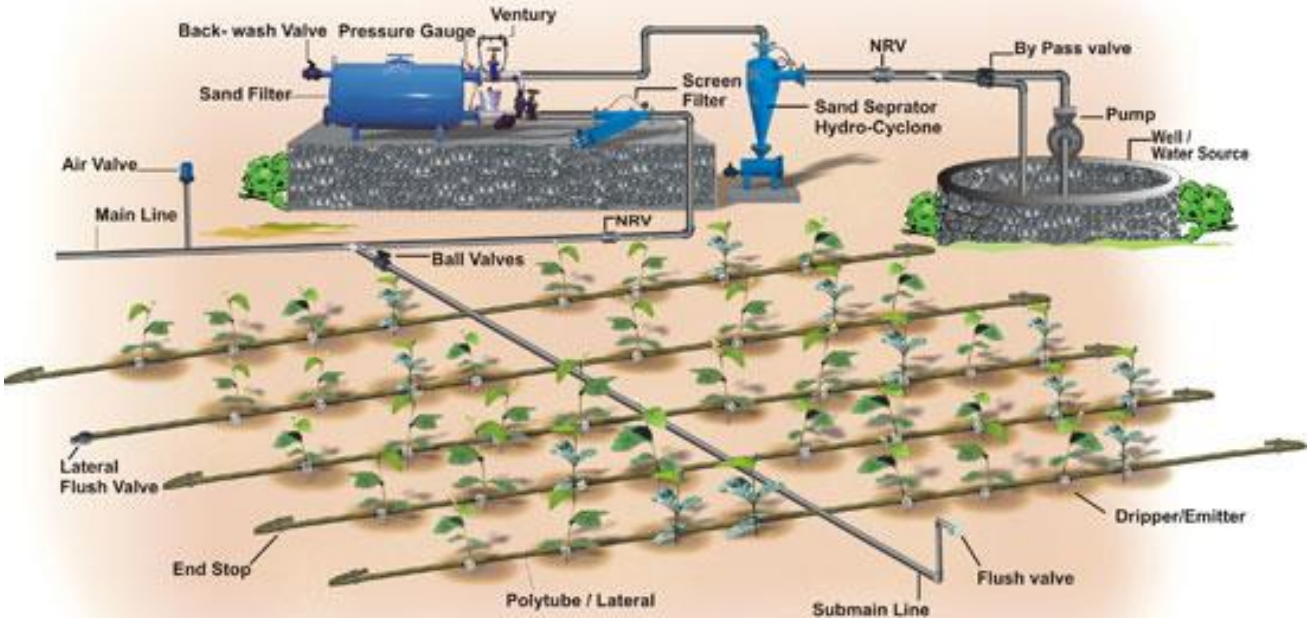
Business Model Canvas

proposed by A. Osterwalder



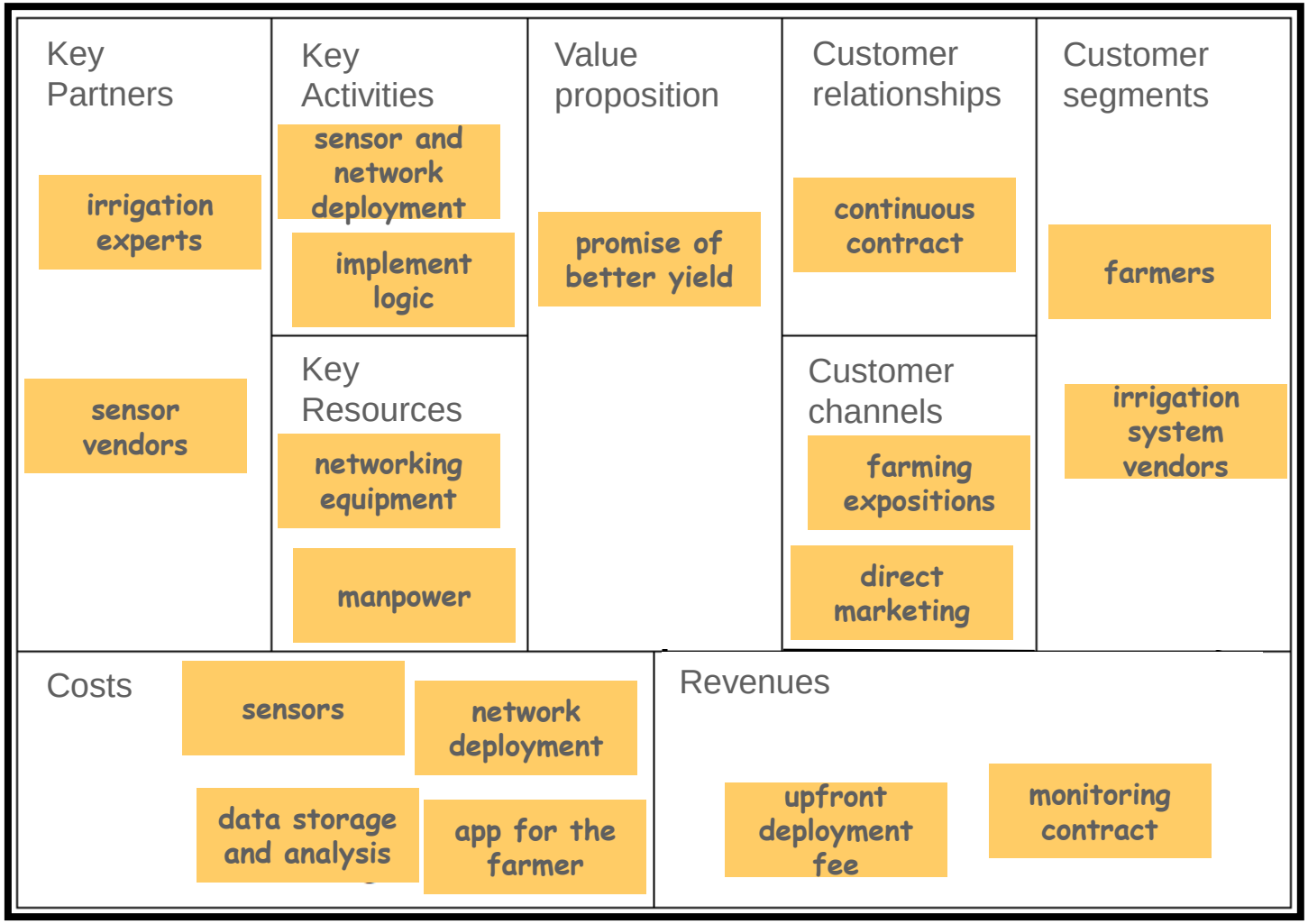
Example: Irrigation monitoring system

smart farming solution based on IoT

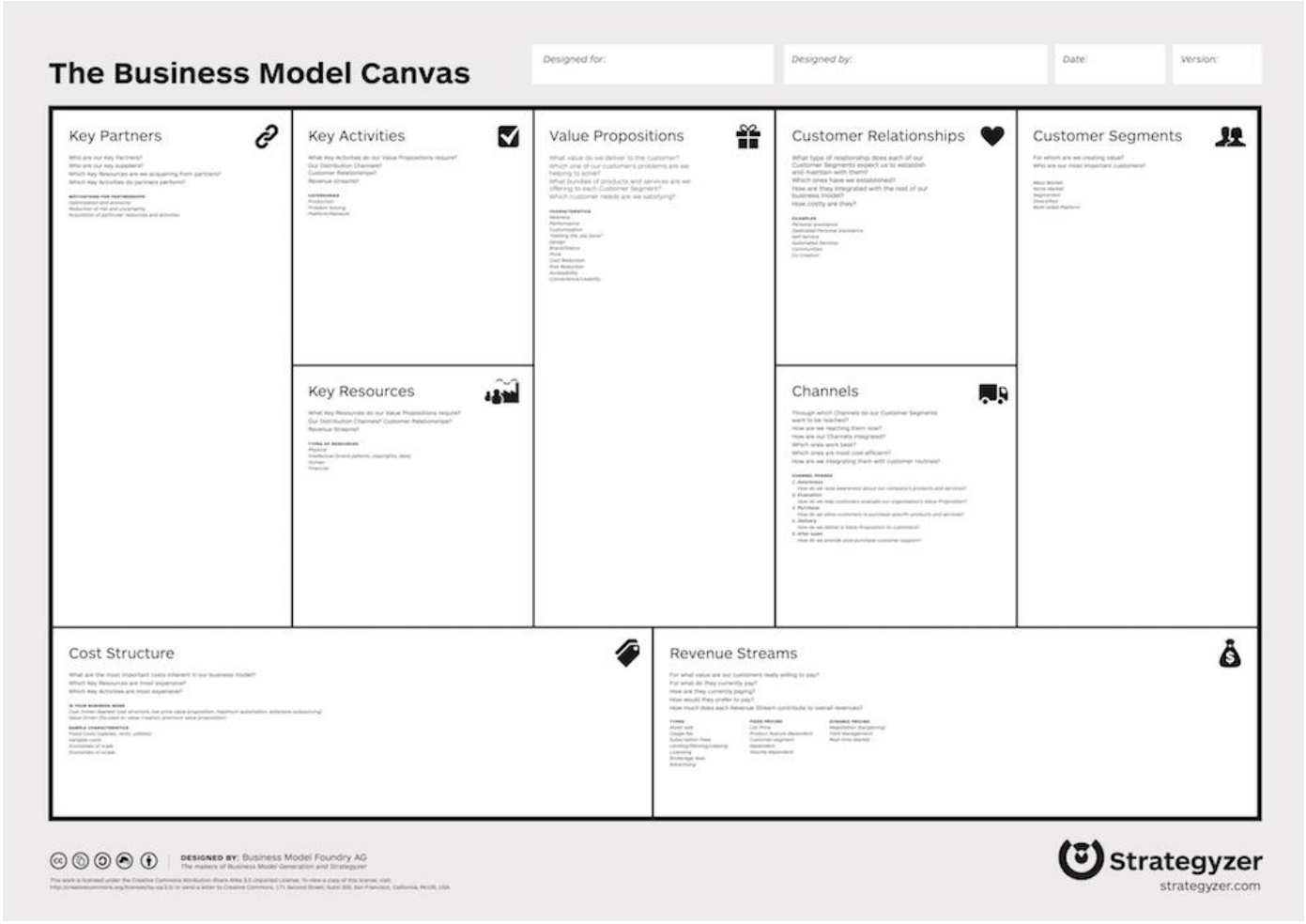


Example: Irrigation monitoring system

business model canvas



Template and explanation available
for business model canvas

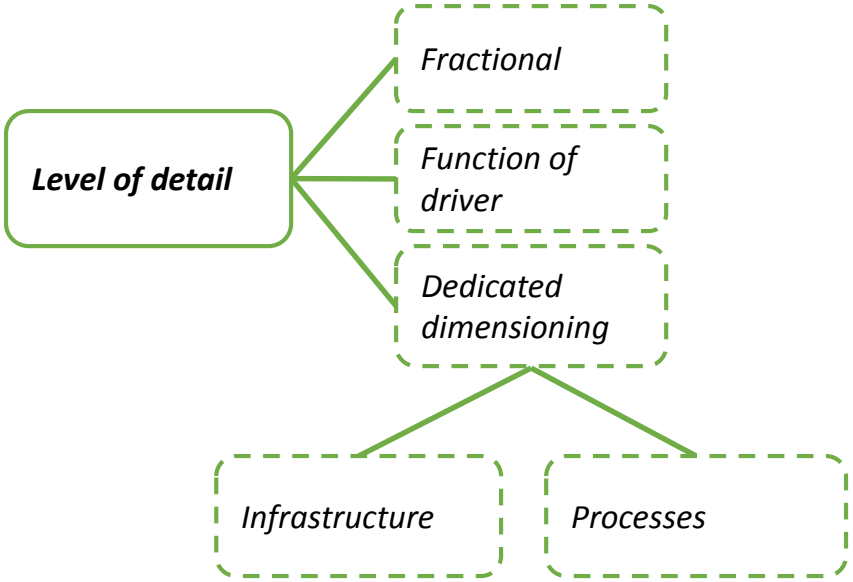


Outline

- What is techno-economic analysis?
- How to make a quick assessment?
- What are appropriate cost models in an investment analysis?
- How to integrate more advanced concepts in an easy way?
- Where to find all information?
- Wrap-up and call for action

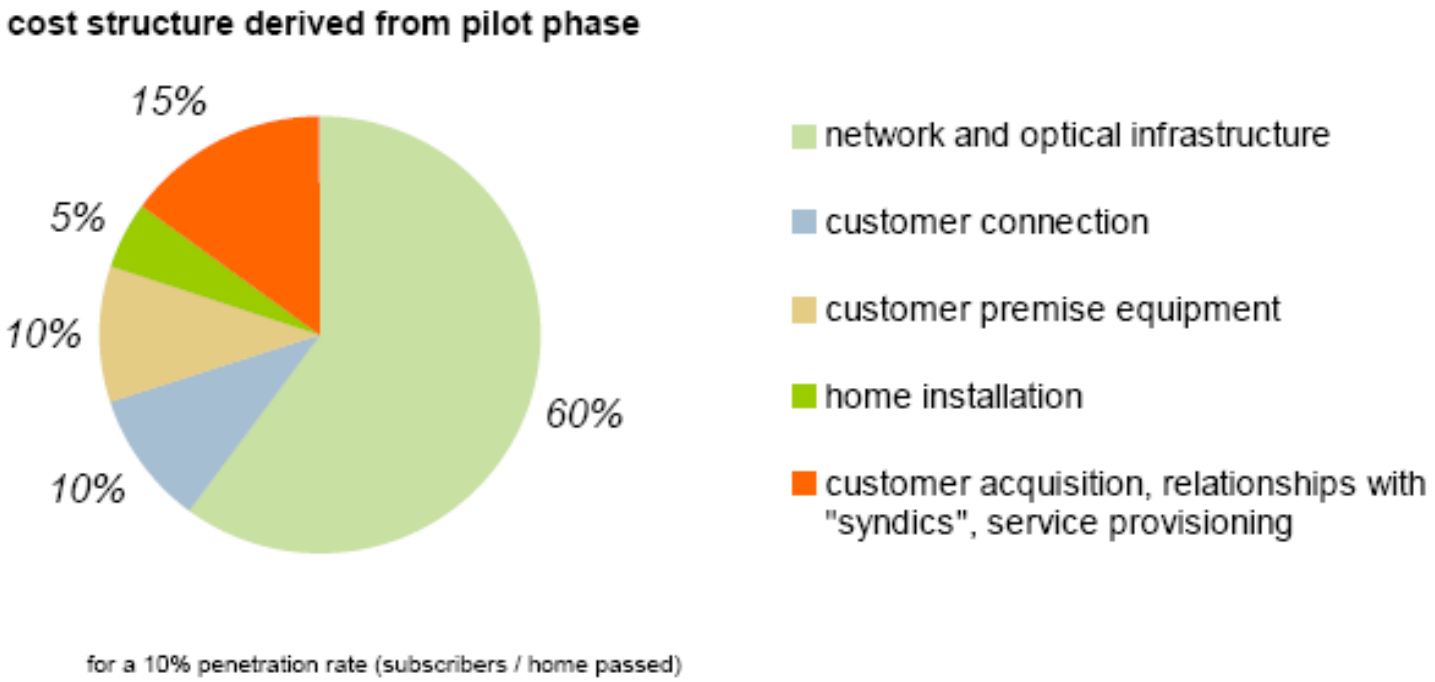
Appropriate level of detail/abstraction

depends on available input data and goal of the model



Fractional cost modeling

is on the highest abstraction level



Source: Orange – from FTTH pilot to pre-rollout in France

Determine fraction of overall costs to allocate to different parts based on previous projects (pilots, other areas, etc)

Function of driver cost modeling

is on the intermediate abstraction level

Examples of drivers:

installation length (50€/m)

customer base (1k €/cust)

…

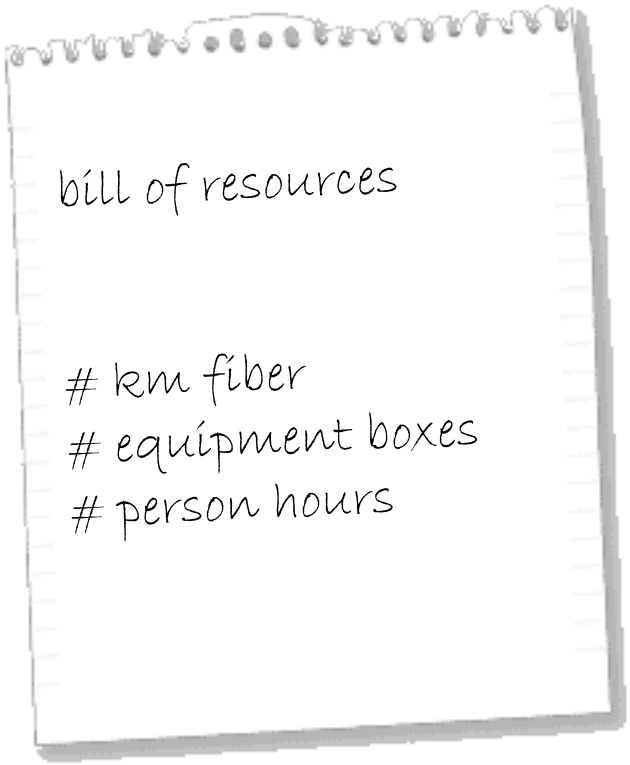
→ combinations possible

Find the parameter that mainly drives the cost

This is the most common cost modeling approach!

Dedicated dimensioning

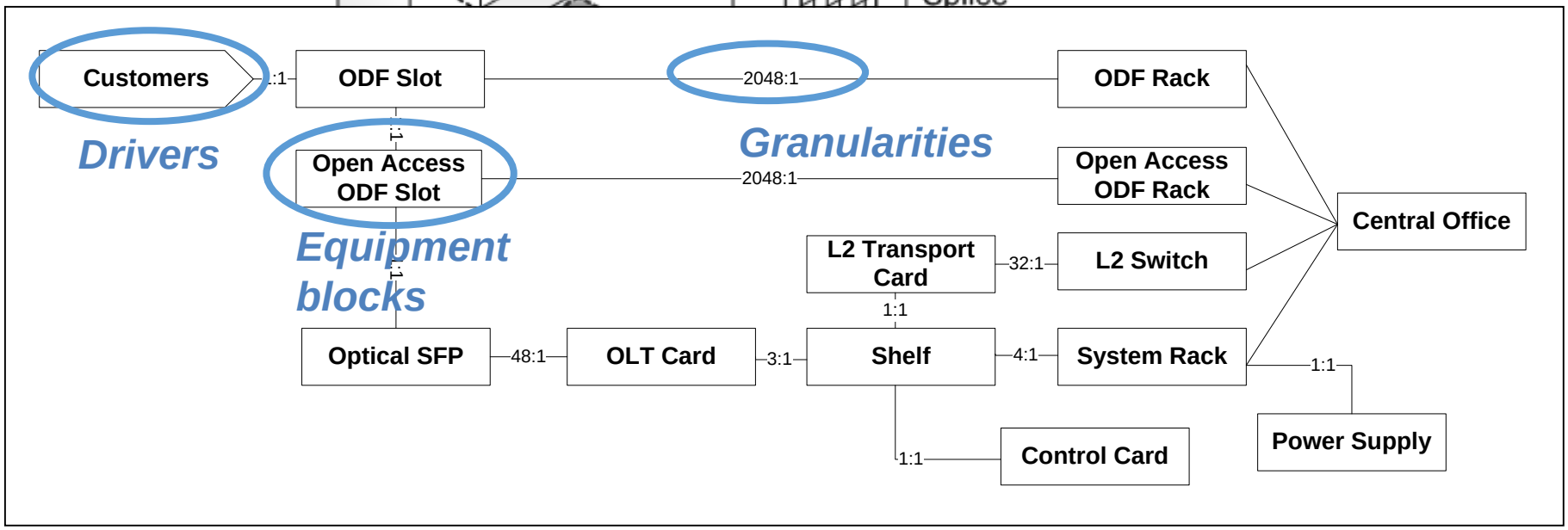
is on the lowest abstraction level, thus gives most detail



Model in detail all resources that you need
based on detailed view of actual implementation

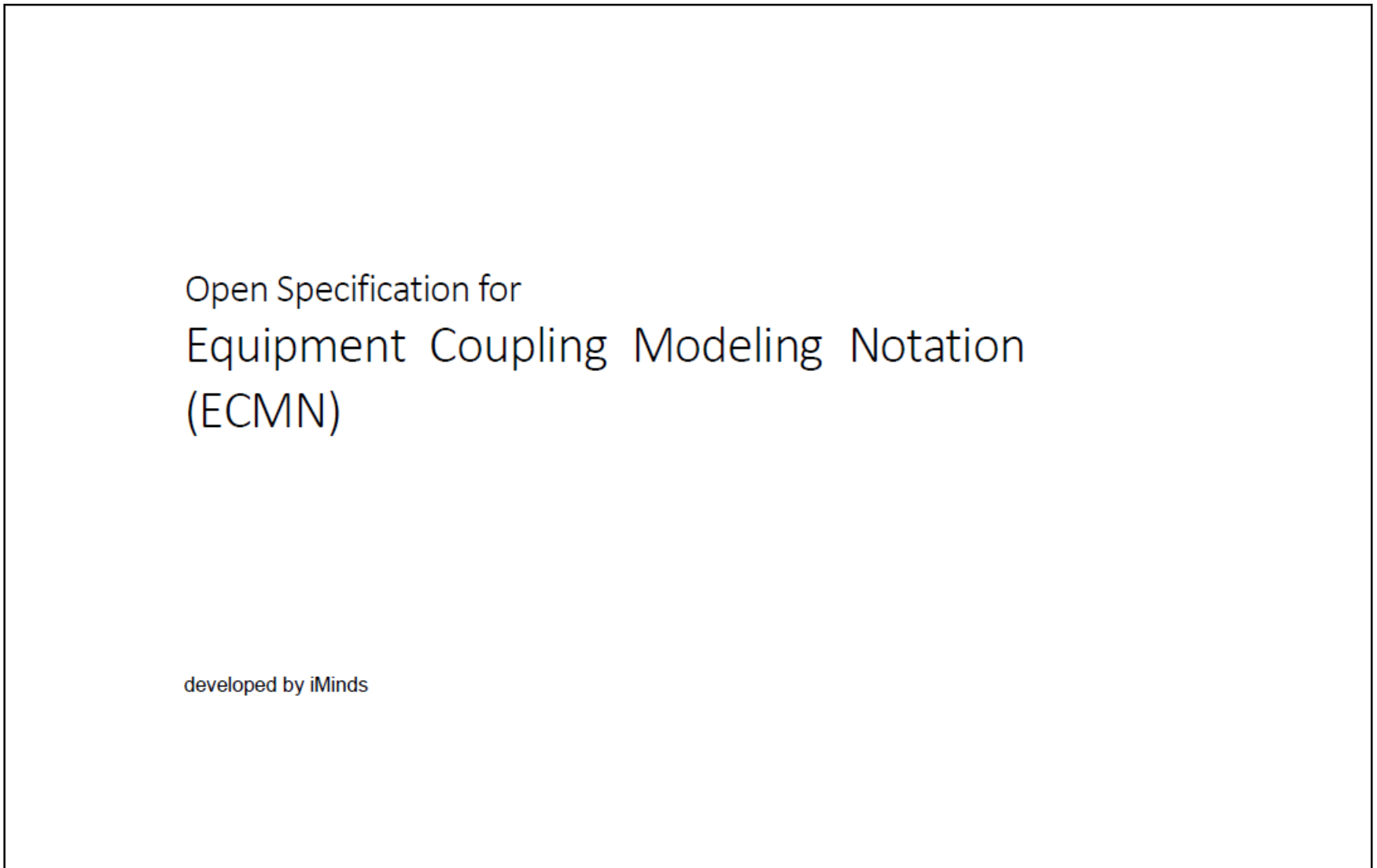
Detailed equipment modeling using ECMN

example: FTTH network



Open ECMN specification available

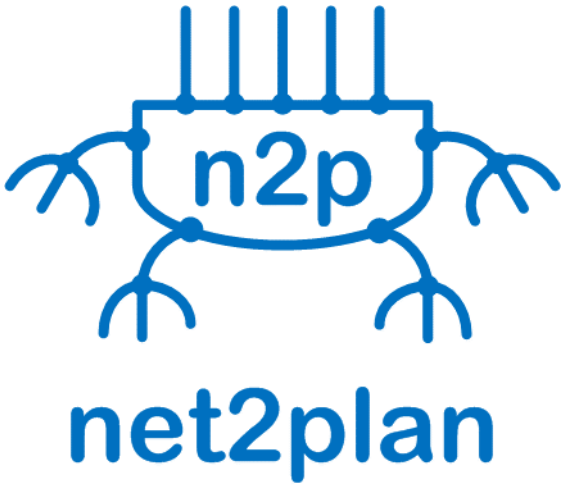
part of FI-ware open specification



Net2Plan tool available

allows to model equipment per year

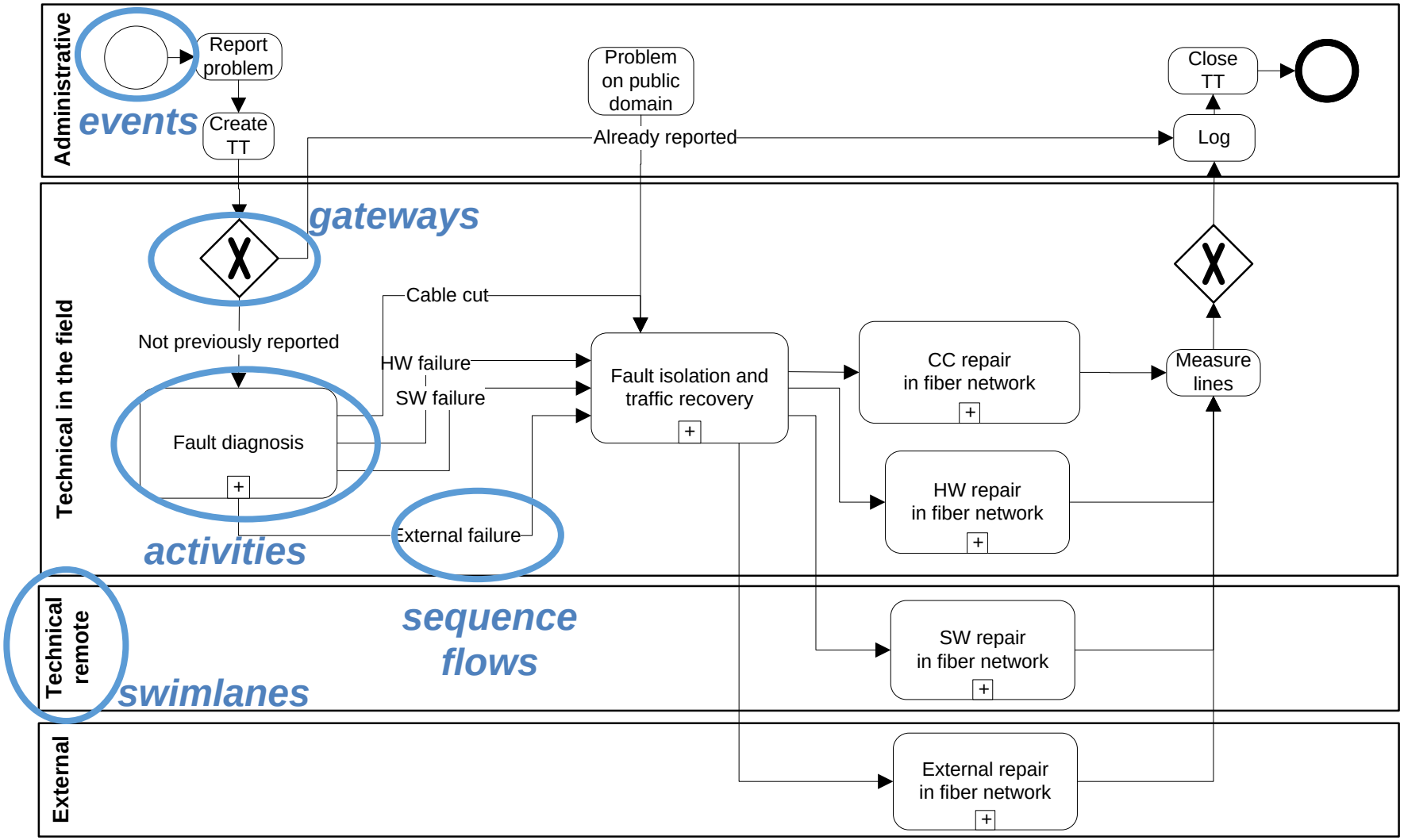
- Planning and evaluation of a multilayer IP-over-WDM network
- Goal
  - Plan and allocate the resources at the IP and optical layers for a given year
  - while minimizing the capital expenditures (CAPEX) cost of the network



- Open source Java tool
- Developed at Universidad Politécnica de Cartagena

Detailed process modeling using BPMN

example: network repair process



Investment decision

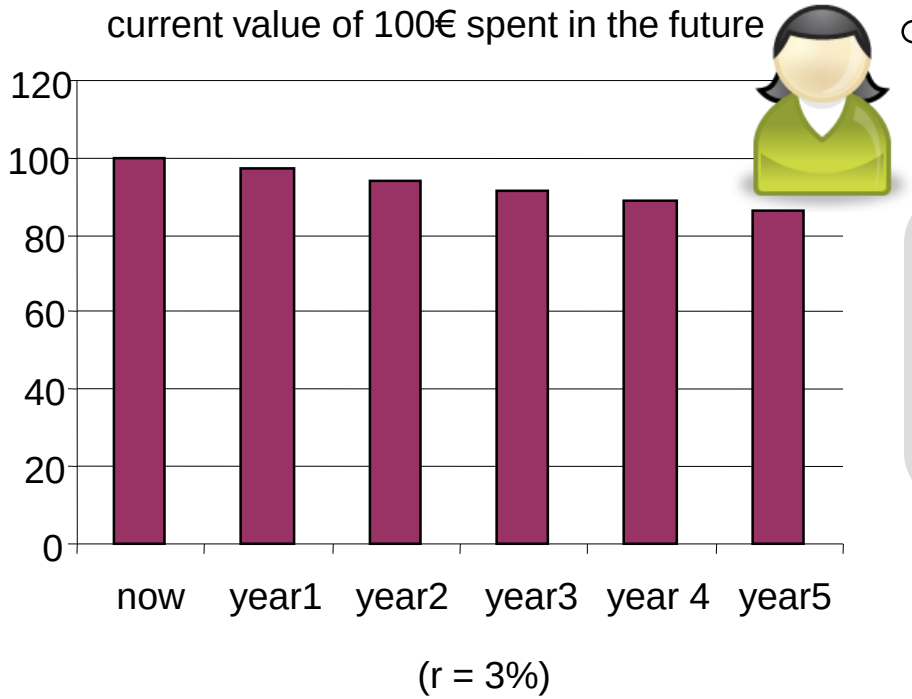
is about comparing incoming and outgoing cash-flows over time

2017 2018 2019 2020 2021

tijd

Net present value

is widely spread investment decision technique

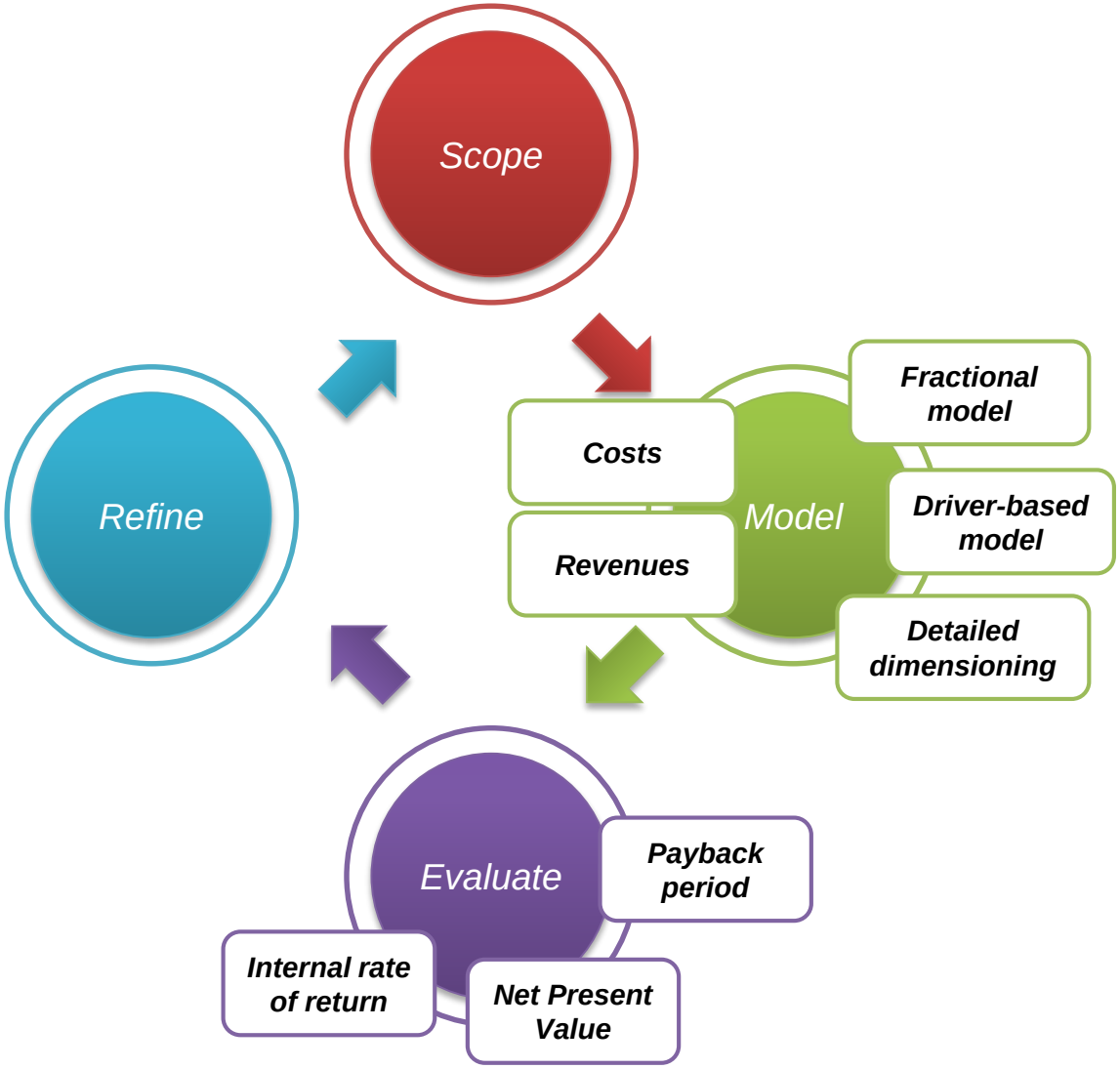


$$C = \frac{F}{(1+i)^n}$$

C = current value
F = future value
i = discount rate
n = time period (years)

White paper and tutorial available

for techno-economic analysis cycle



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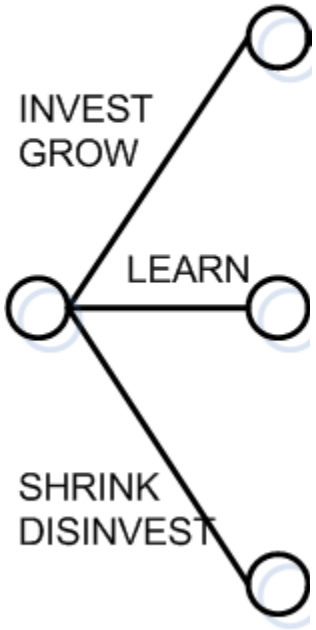
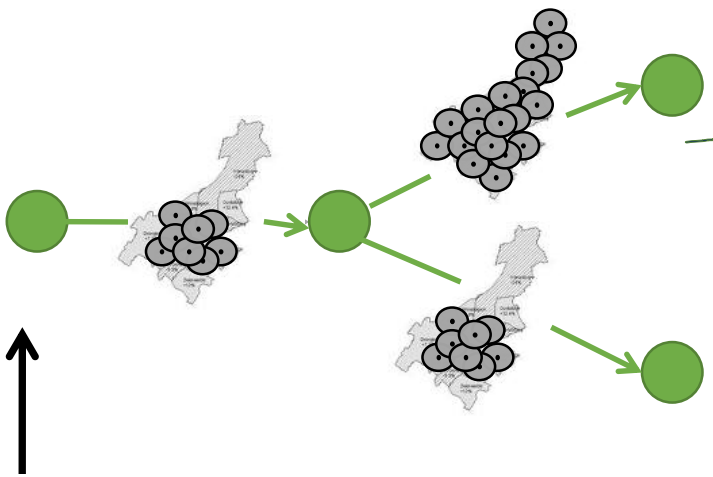
Real option theory

makes a distinction between 7 typical types of options (7S)

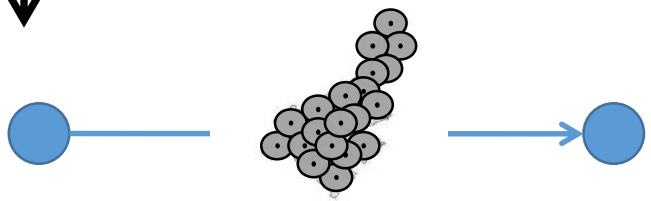


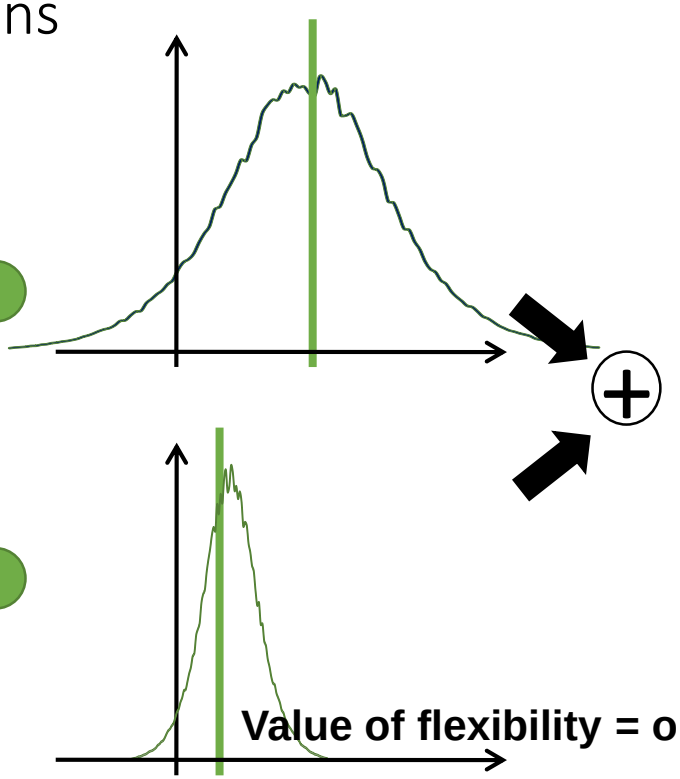
Flexible roll-out gives value

as shown by real options

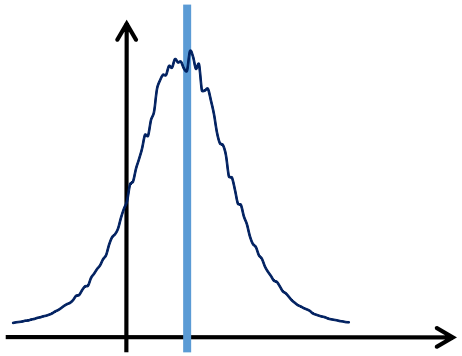


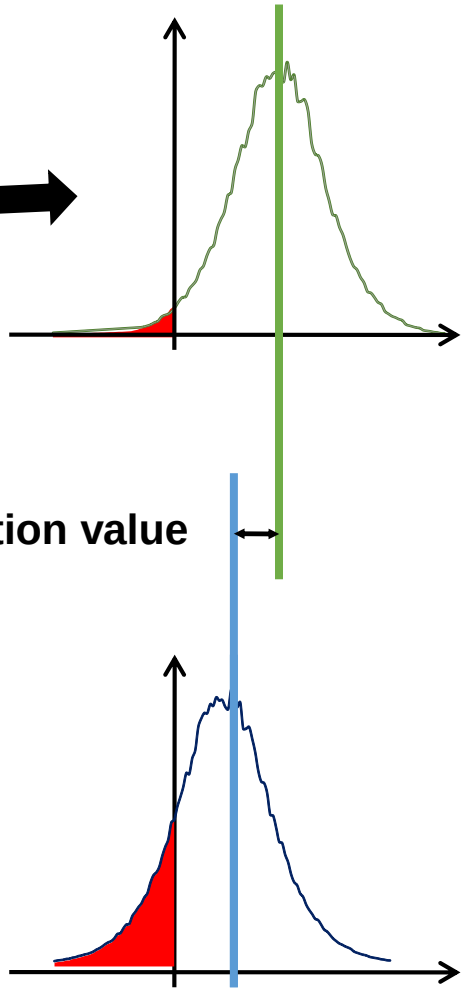
phased decision
vs.
static roll-out





Value of flexibility = option value





Tutorial paper and presentation available

concerning practical use of real options in ICT projects

Real Options in Telecom Infrastructure Projects - A Tutorial

Mathieu Tahon, Sofie Verbrugge, Peter J. Willis, Paul Botham, Didier Colle, Mario Pickavet, Piet Demeester, *IEEE Fellow*

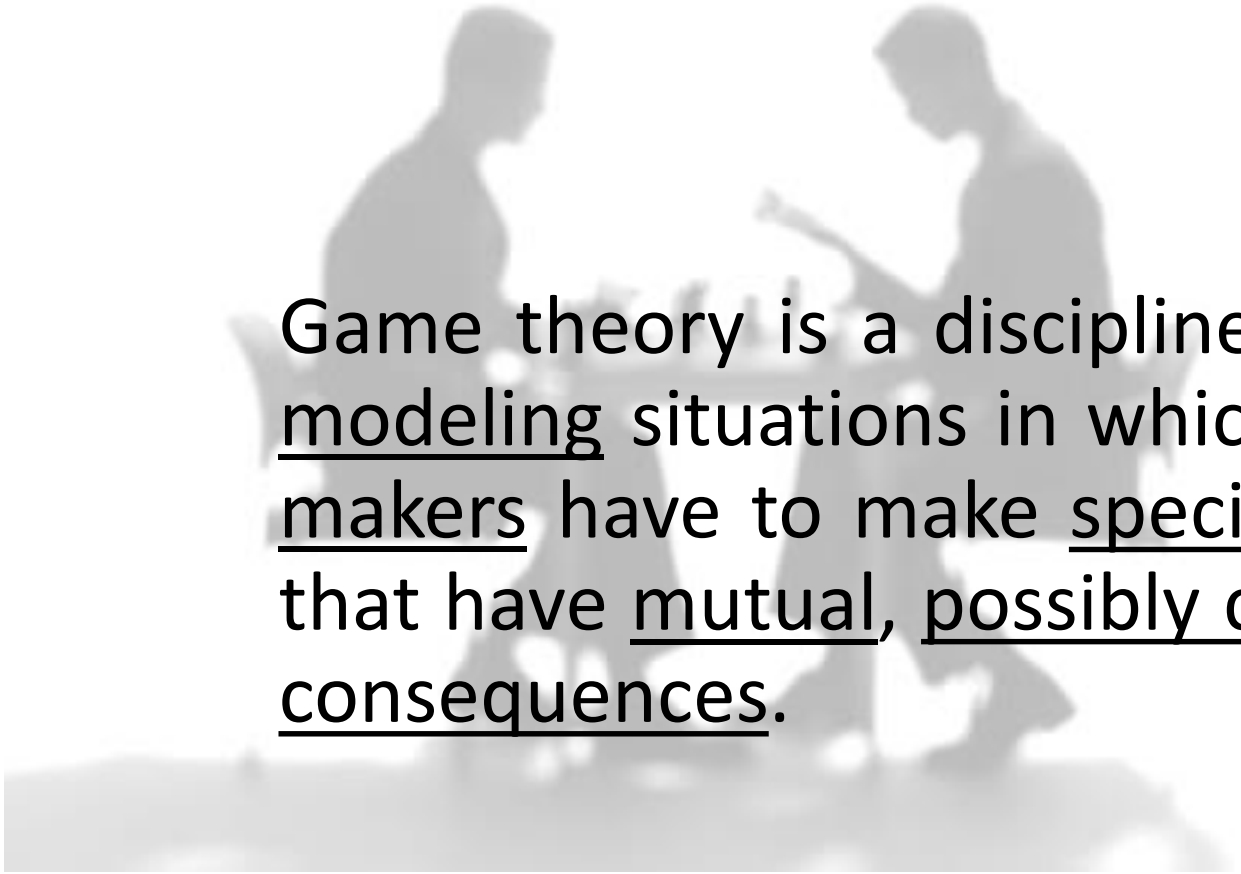
***Abstract*—The rapid technological change and uncertain future evolutions have a large impact on investment projects in the telecommunication sector. When new infrastructure networks are rolled out, the initial assumptions can prove to be untrue in the future, severely impacting the payoff. It is therefore extremely important that projects offer flexibility to allow the management to react to unforeseen changes. Management must, for example, be able to decide to speed up the project, slow it down, or even completely abandon it. However, the standard method used to evaluate investment projects, the Net Present Value analysis, is unable to capture the value of these different flexibility options. The Real Option concept, derived from financial literature, was proposed as a solution and implements this flexibility in the standard calculations. However, the Real Option Theory is only slowly getting accepted within the telecommunication sector. In this paper, we introduce the basics of real options theory and**

license is a straightforward example as it offers the flexibility to decide when and where to roll out the mobile network. The 4G mobile operator can start with a study period, testing the new technology in small areas. When the uptake of 4G services proves to be exceeding initial expectations, extra investments can be made to speed up the rollout of the nationwide network. On the other hand, when a telecom project proves to be unprofitable, the management can decide to abandon it completely. For example, only one year after its launch, British Telecom decided to stop its mobile broadcast TV service in 2007.

All investment problems are economically assessed before they are started. In general, this analysis consists of predicting the future costs and revenues of the investment project.

Game theory

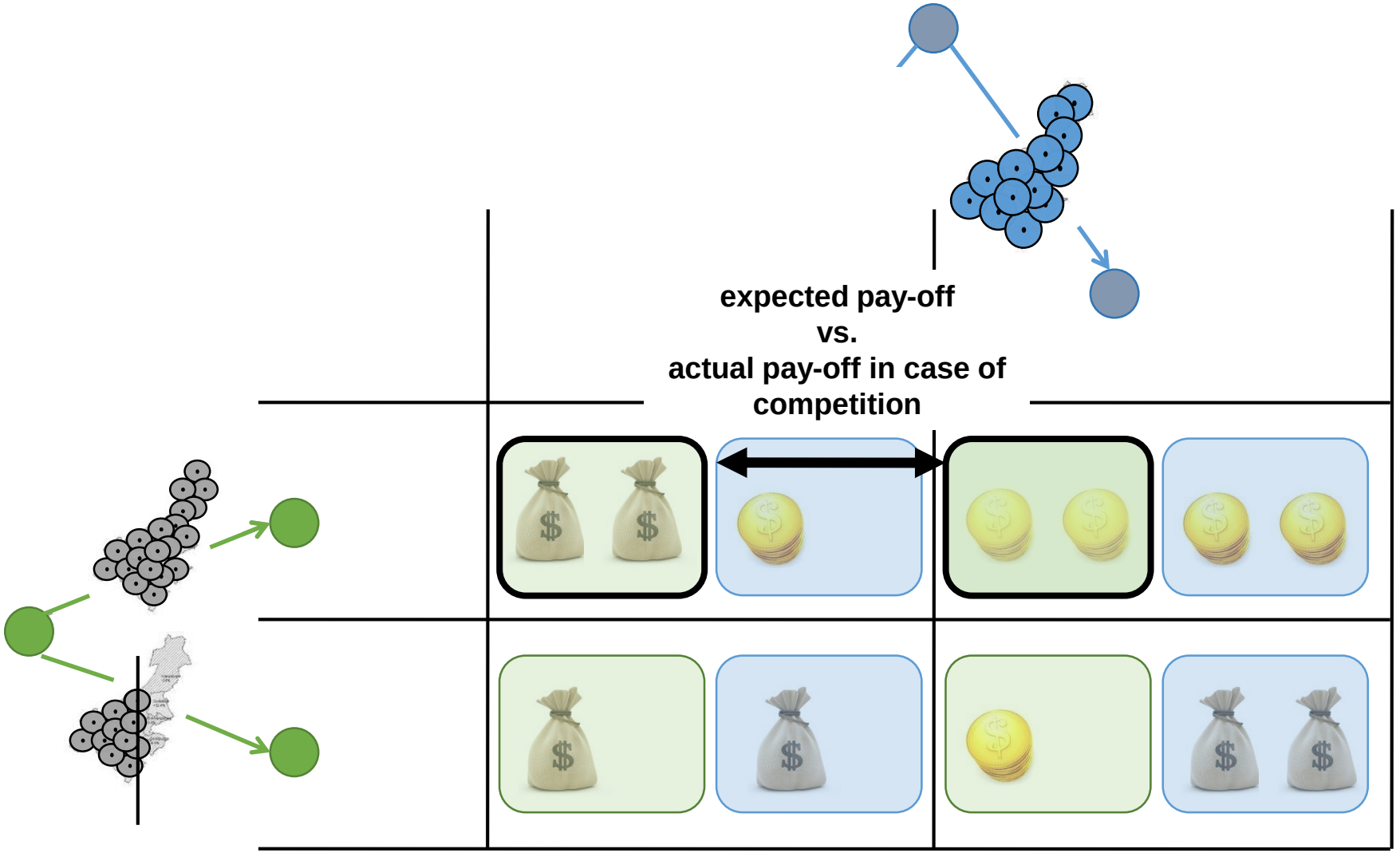
models the impact of interaction



Game theory is a discipline aimed at modeling situations in which decision makers have to make specific actions that have mutual, possibly conflicting, consequences.

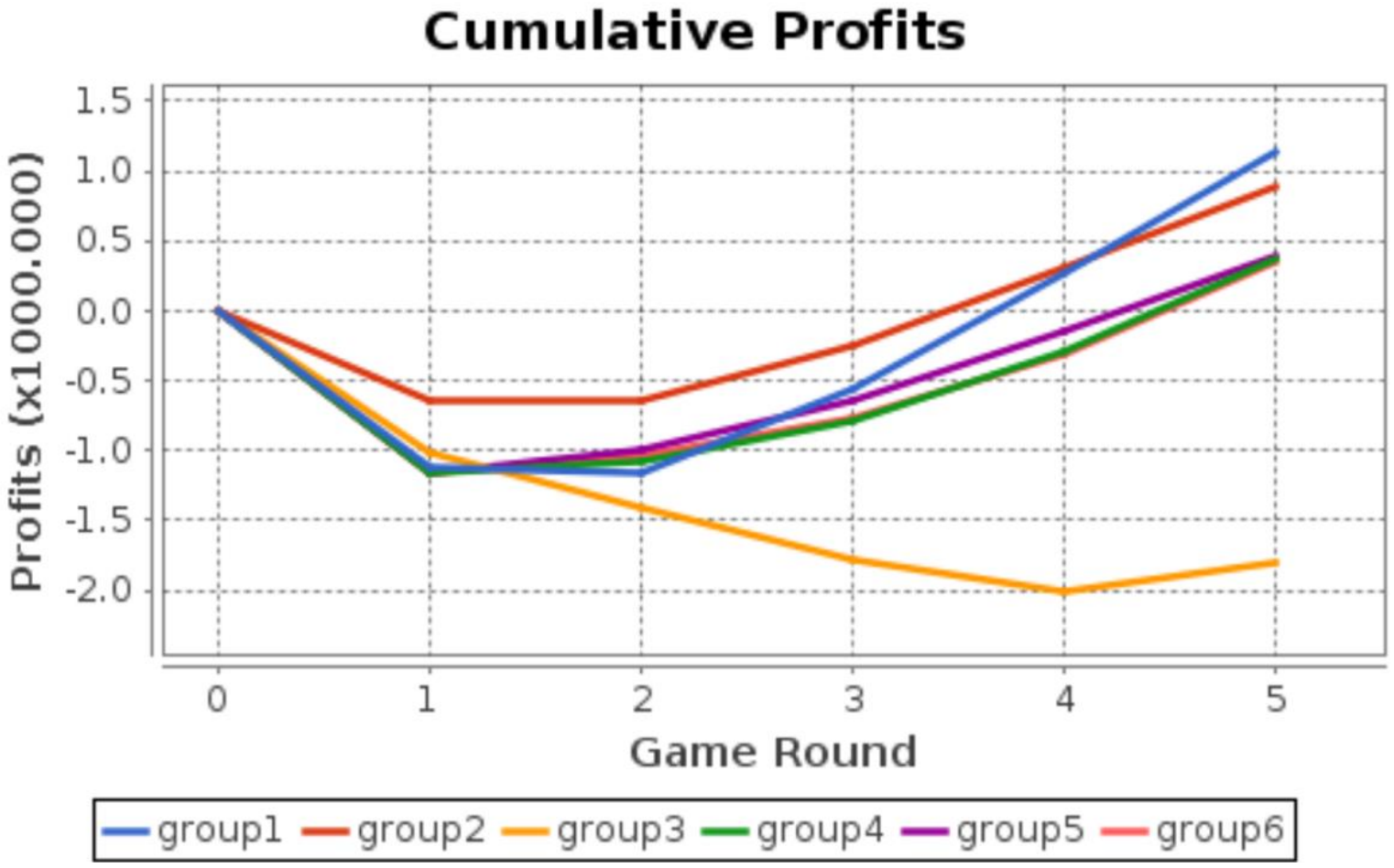
Competition has big impact

as shown by game theory



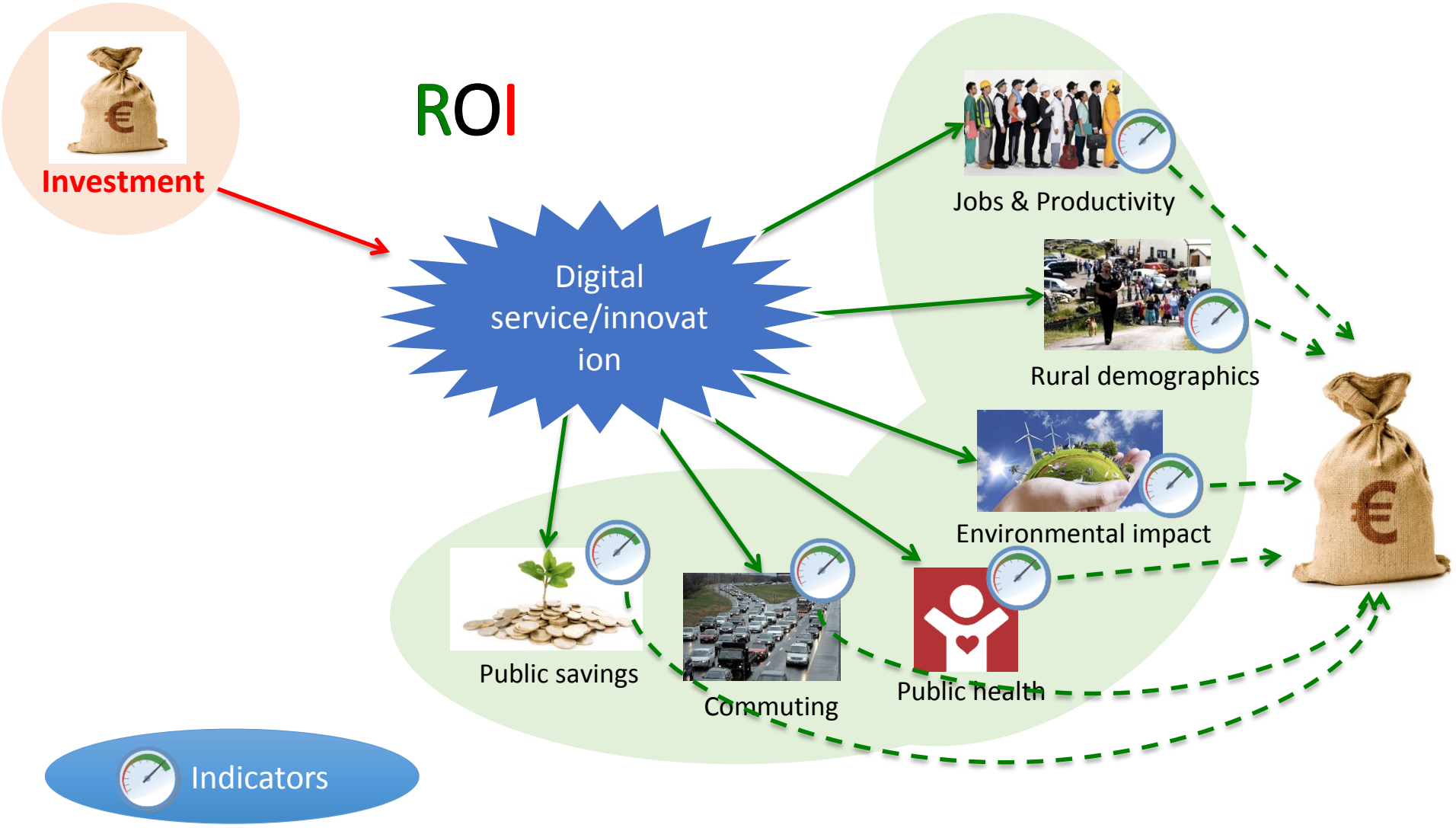
Online business game available

for integration in Master course



Indirect effects can be modeled

by socio-economic return on investment indicators (SEROI)



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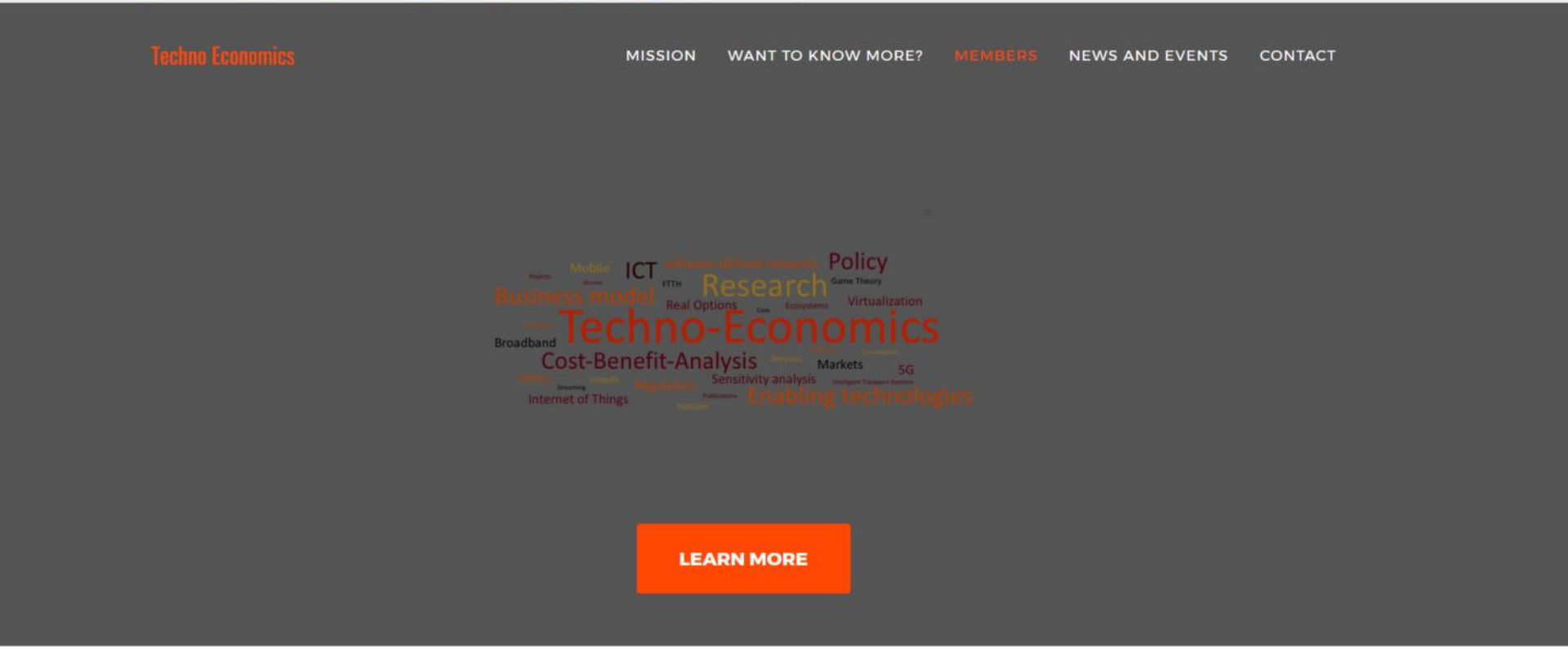

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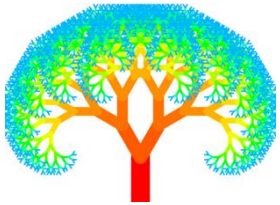

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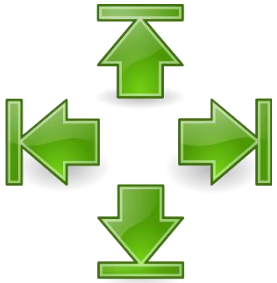
Standard approaches can help

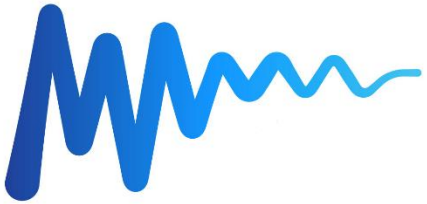
in order to tackle difficulties in techno-economic research

Multi-actor

Uncertainty



Case-specific constraints



Dynamics

Common templates and tools

needed in order to take techno-economics research to next level

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Do you want to join?
Do you have any questions?

sofie.verbrugge@ugent.be

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International Conference on Design of Reliable Communication Networks 2017

8-10 March 2017, Munich, Germany

	Wednesday, March 8	Thursday, March 9	Friday, March 10
9:00 - 10:00 am		*Keynote 1*	*Keynote 2*
10:00 - 10:30 am		*Coffee Break*	*Coffee Break*
10:30 - 11:00 am		*Invited Talk Session 1*	*Invited Talk Session 4*
11:00 am - 12:00 pm		*Session 1 - Transport*	*Session 4 - Disaster*
12:00 - 1:00 pm		*Lunch*	*Lunch*
1:00 - 1:30 pm		*Invited Talk Session 2*	*Invited Talk Session 5*
1:30 - 2:30 pm		*Session 2 - Modeling*	*Session 5 - 5G*
2:30 - 3:00 pm		*Coffee Break*	*DRCN Best Paper Award and Closing Ceremony*
3:00 - 3:15 pm	*Opening*	*Session 3 - Security*	*Coffee Break*
3:15 - 3:30 pm	*Tutorials*		
3:30 - 5:00 pm			*RECODIS Session at DRCN*
5:00 - 6:00 pm		*Panel Discussion on "Reliable 5G Networks"*	
6:00 - 7:00 pm	*Welcome Reception*		
7:00 - 8:00 pm			

8:00 - 9:00 pm *Conference Dinner*

9:00 - 11:00 pm

Wednesday, March 8

Wednesday, March 8, 15:00 - 15:15

Wednesday, March 8, 15:15 - 18:00

Tutorials TOP

Wednesday, March 8, 18:00 - 21:00

Thursday, March 9

Thursday, March 9, 09:00 - 10:00

Keynote 1 TOP

Thursday, March 9, 10:00 - 10:30

Thursday, March 9, 10:30 - 11:00

Invited Talk Session 1 TOP

Designing a Resilient Virtual Topology in a Multi-Layer Datacenter Interconnection Network
Yuri Smirnov (Facebook Inc, USA)

Thursday, March 9, 11:00 - 12:00

Session 1 - Transport TOP

Comparison of Various Reliable Transport Architectures for Long-Haul Networks
Onur Turkcu, Abishek Gopalan, Biao Lu and Parthiban Kandappan (Infinera, USA)

A Multiple-Link Failures Enumeration Approach for Availability Analysis on Partially Disjoint Paths
Nehuen Gonzalez-Montoro (National University of Córdoba & IDIT - CONICET, Argentina); Renato Cherini (National University of Córdoba, Argentina); Jorge M Finochietto (National University of Córdoba & CONICET, Argentina)

Connection Management in a Resilient Transport Protocol
Truc Anh N. Nguyen (The University of Kansas, USA); James P. G. Sterbenz (University of Kansas & Lancaster University (UK), USA)

Thursday, March 9, 12:00 - 13:00

Lunch TOP

Thursday, March 9, 13:00 - 13:30

Invited Talk Session 2 TOP

Thursday, March 9, 13:30 - 14:30

Session 2 - Modeling TOP

Finding Minimum Node Separators: A Markov Chain Monte Carlo Method
Joohyun Lee (The Ohio State University, USA); Jaewook Kwak (North Carolina State University, USA); Hyang-Won Lee (Konkuk University, Korea); Ness B. Shroff (The Ohio State University, USA)

Modelling Spectrum Assignment in a Two-Service Flexi-Grid Optical Link with Imprecise Continuous-Time Markov Chains
Cristina E.M. Rottondi (Dalle Molle Institute for Artificial Intelligence (IDSIA), Switzerland); Alexander Erreygers (Ghent University, Belgium); Giacomo Verticale (Politecnico di Milano, Italy); Jasper De Bock (Ghent University, Belgium)

Routing Optimization for SDN Networks Based on Pivoting Rules for the Simplex Algorithm
Fabien Geyer (Airbus Group Innovations, Germany)

Thursday, March 9, 14:30 - 15:00

Coffee Break TOP

Thursday, March 9, 15:00 - 17:00

Session 3 - Security TOP

Towards Cloud Security Improvement with Encryption Intensity Selection
Mortada Aman and Egemen K. Çetinkaya (Missouri University of Science and Technology, USA)

Using SEIRS Epidemic Models for IoT Botnets Attacks
M. Todd Gardner (University of Missouri, Kansas City & Federal Aviation Administration, USA); Cory Beard and Deep Medhi (University of Missouri-Kansas City, USA)

Spectral Analysis of Backbone Networks Against Targeted Attacks
Tristan Shatto and Egemen K. Çetinkaya (Missouri University of Science and Technology, USA)

Improving the Robustness to Targeted Attacks in Software Defined Networks (SDN)
Diego F. Rueda and Eusebi Calle (University of Girona, Spain); Jose Luis Marzo (Universitat de Girona, Spain)

Thursday, March 9, 17:00 - 19:00

Panel Discussion on "Reliable 5G Networks" TOP

Thursday, March 9, 20:00 - 23:00

Conference Dinner TOP

Friday, March 10

Friday, March 10, 09:00 - 10:00

Keynote 2 TOP

Multi-layer resilience schemes and their control plane support
Victor Lopez (Telefonica, Spain)

Friday, March 10, 10:00 - 10:30

Coffee Break TOP

Friday, March 10, 10:30 - 11:00

Invited Talk Session 4 TOP

Friday, March 10, 11:00 - 12:00

Session 4 - Disaster TOP

Analysis of Node-Resilience Strategies under Natural Disasters
Manuel Aprile (École Polytechnique Fédérale de Lausanne, Switzerland); Natalia Castro (Universidad de la República, Uruguay); Franco Robledo (Facultad de Ingeniería, Universidad de la República, Uruguay); Pablo Gabriel Romero (Universidad de la República, Uruguay)

Determination of the Minimum Cost Pair of D-Geodiverse Paths
Amaro F. de Sousa (Institute of Telecommunications, University of Aveiro, Portugal); Dorabella Santos (Instituto de Telecomunicações - Pólo de Aveiro, Portugal); Paulo P Monteiro (Universidade de Aveiro & Instituto de Telecomunicações, Portugal)

Multi-Carrier Interconnection-based Emergency Packet Transport Network Planning in Disaster Recovery
Sugang Xu (National Institute of Information and Communications Technology, Japan); Noboru Yoshikane (KDDI Research, Inc., Japan); Masaki Shiraiwa (National Institute of Information and Communications Technology, Japan); Takehiro Tsuritani (KDDI R&D Laboratories, Inc., Japan); Hiroaki Harai (National Institute of Information and Communications Technology, Japan); Yoshinari Awaji (National Institute of Information and Communications Technology (NICT), Japan); Naoya Wada (NICT, Japan)

Friday, March 10, 12:00 - 13:00

Lunch TOP

Friday, March 10, 13:00 - 13:30

Invited Talk Session 5 TOP

Friday, March 10, 13:30 - 14:30

Session 5 - 5G TOP

Survivable BBU Hotel placement in a C-RAN with an Optical WDM Transport
Bahare Masood Khorsandi and Carla Raffaelli (University of Bologna, Italy); Lena Wosinska and Paolo Monti (KTH Royal Institute of Technology, Sweden); Matteo Fiorani (Ericsson Research, Sweden)

Survivability of Fixed Mobile Convergent Access Networks
Attila Mitcsenkov and Tibor Cinkler (Budapest University of Technology and Economics, Hungary); Achille Pattavina and Francesco Musumeci (Politecnico di Milano, Italy)

AI for SLA Management in Programmable Networks
Imen Grida Ben Yahia (Orange Labs, France); Jaafar Bendriss (Orange Lab, France); Prosper Chemouil (Orange Labs & OLN/CNC, France); Djamal Zeghlache (Institut Mines-Telecom, Telecom SudParis & UMR 5157 CNRS - Samovar, France)

Friday, March 10, 14:30 - 15:00

DRCN Best Paper Award and Closing Ceremony TOP

Friday, March 10, 15:00 - 15:30

Coffee Break TOP

Friday, March 10, 15:30 - 17:00

RECODIS Session at DRCN TOP

The Robust Node Selection Problem aiming to Minimize the Connectivity Impact of any Set of p Node Failures
Amaro F. de Sousa (Institute of Telecommunications, University of Aveiro, Portugal); Deepak Mehta (United Technologies Research Centre, Ireland); Dorabella Santos (Instituto de Telecomunicações - Pólo de Aveiro, Portugal)

A repeated game formulation of network embedded coding for multicast resilience in extreme conditions
Christian Esposito (University of Salerno, Italy); Aniello Castiglione and Francesco Palmieri, CG (Università di Salerno, Italy); Florin Pop (University Politehnica of Bucharest, Romania); Jacek Rak

(Gdansk University of Technology, Poland)

Interdependence between Power Grids and Communication Networks: A Resilience Perspective

Lúcia Martins (University of Coimbra & INESC-Coimbra, Portugal); Rita Girão-Silva (FCTUC, University of Coimbra & INESC-Coimbra, Portugal); Álvaro Gomes (FCTUC, Portugal); Luisa Maria Garcia Jorge (IPB & INESC Coimbra, Portugal); Francesco Musumeci (Politecnico di Milano, Italy); Jacek Rak (Gdansk University of Technology, Poland)

Enumerating Shared Risk Link Groups of Circular Disk Failures Hitting k nodes

Balázs Vass (Budapest University of Technology and Economics, Hungary); Erika R. Bérczi-Kovács (Eötvös University, Budapest, Hungary); János Tapolcai (Budapest University of Technology and Economics, Hungary)