

Techno-economic analysis of reliable ICT networks and services

Sofie Verbrugge

Invited talk DRCN2017
Munich, Germany, March 9th 2017

Techno-economic analysis

supports investment decisions

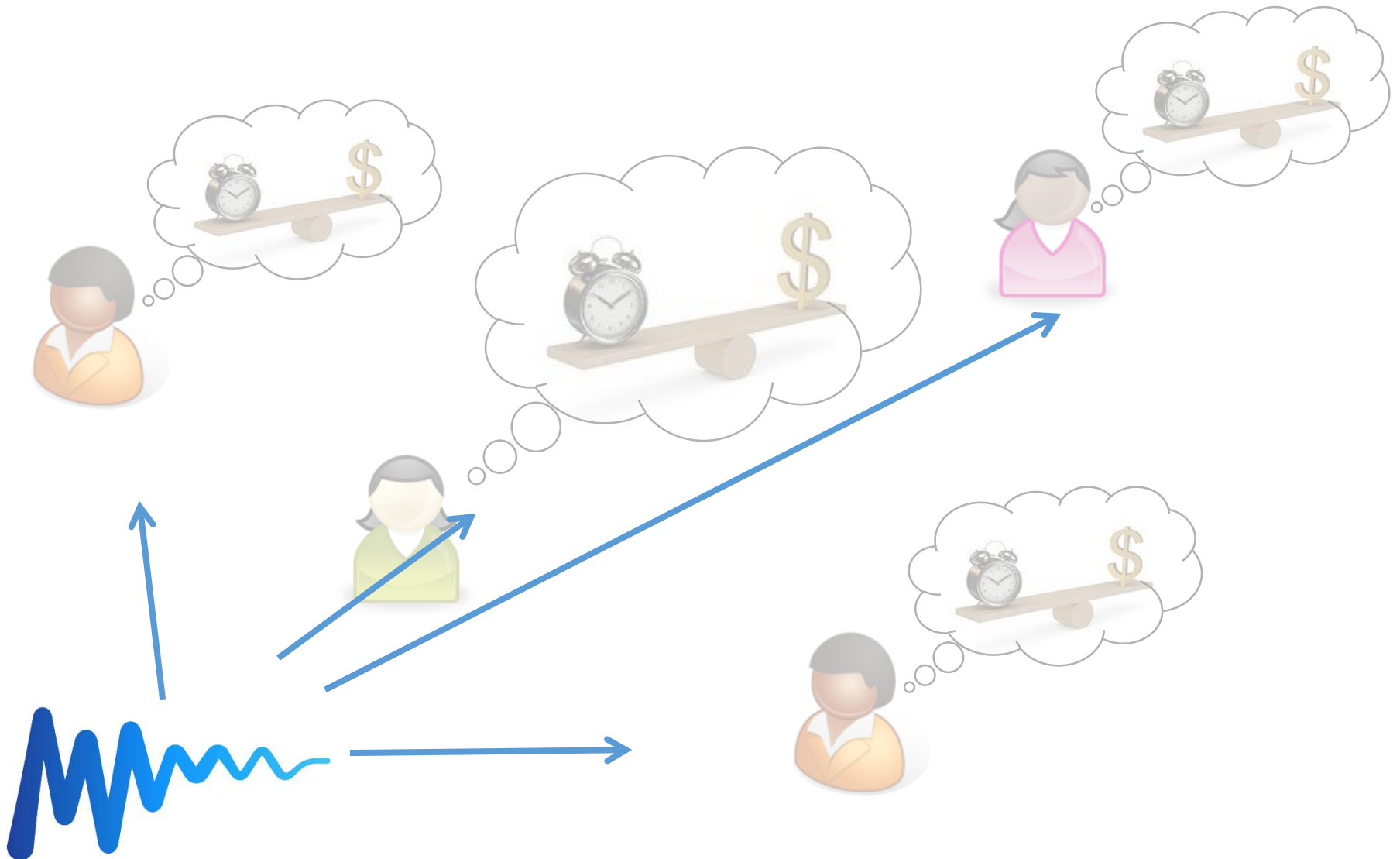


Techno-economic analysis is always done in a multi-actor context



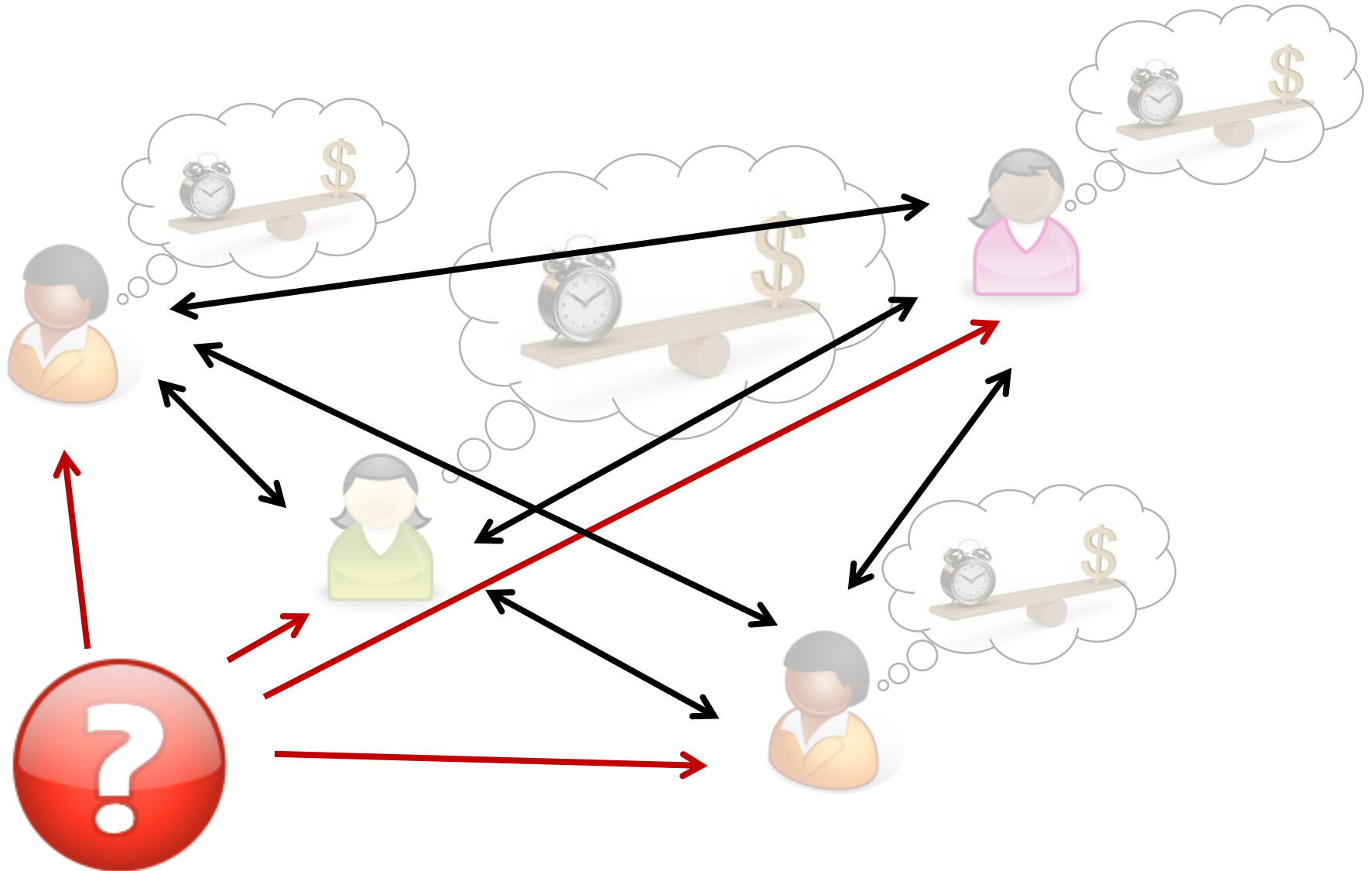
Techno-economics analysis

deals with expected market and customer dynamics



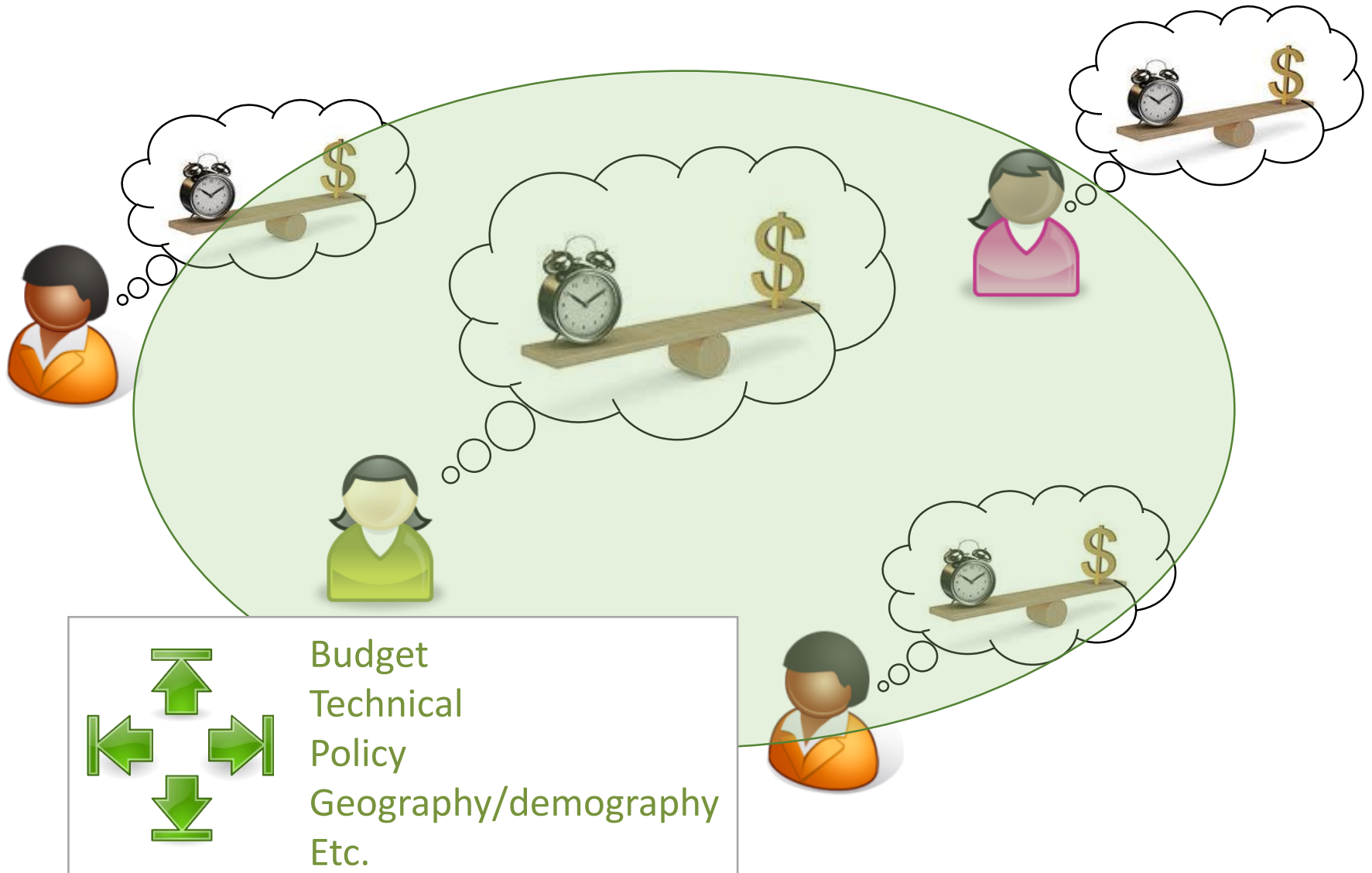
Techno-economics analysis

takes the impact of uncertain changes into account



Techno-economics analysis

needs to adapt to boundary conditions

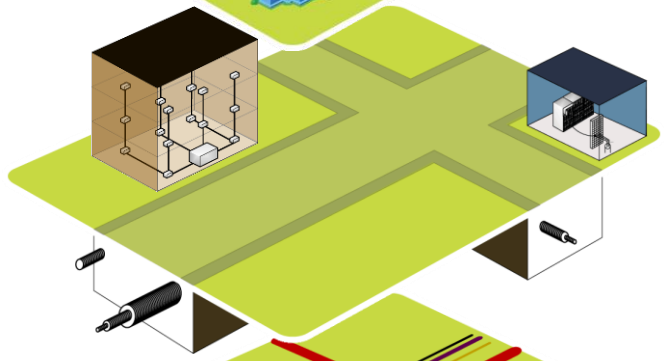


Investment decision based on innovation can be situated on different layers in the network stack

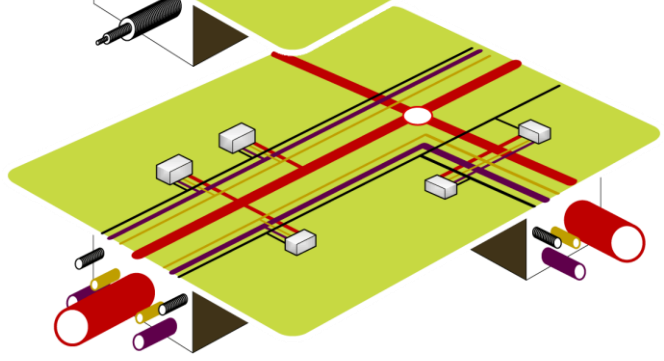
Service deployment
and operations



Network
deployment



Infrastructure
deployment

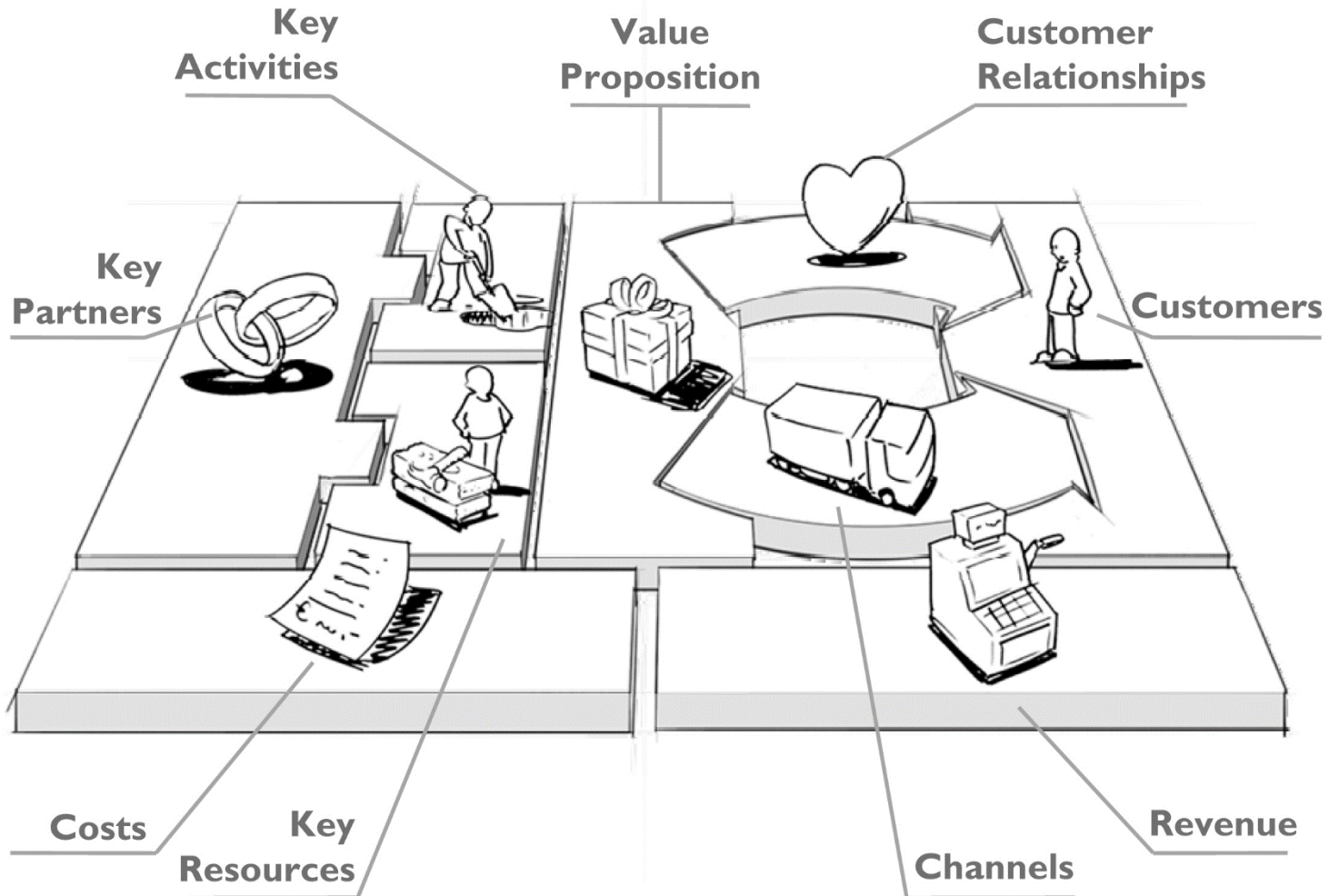


Outline

- What is techno-economic analysis?

Business Model Canvas

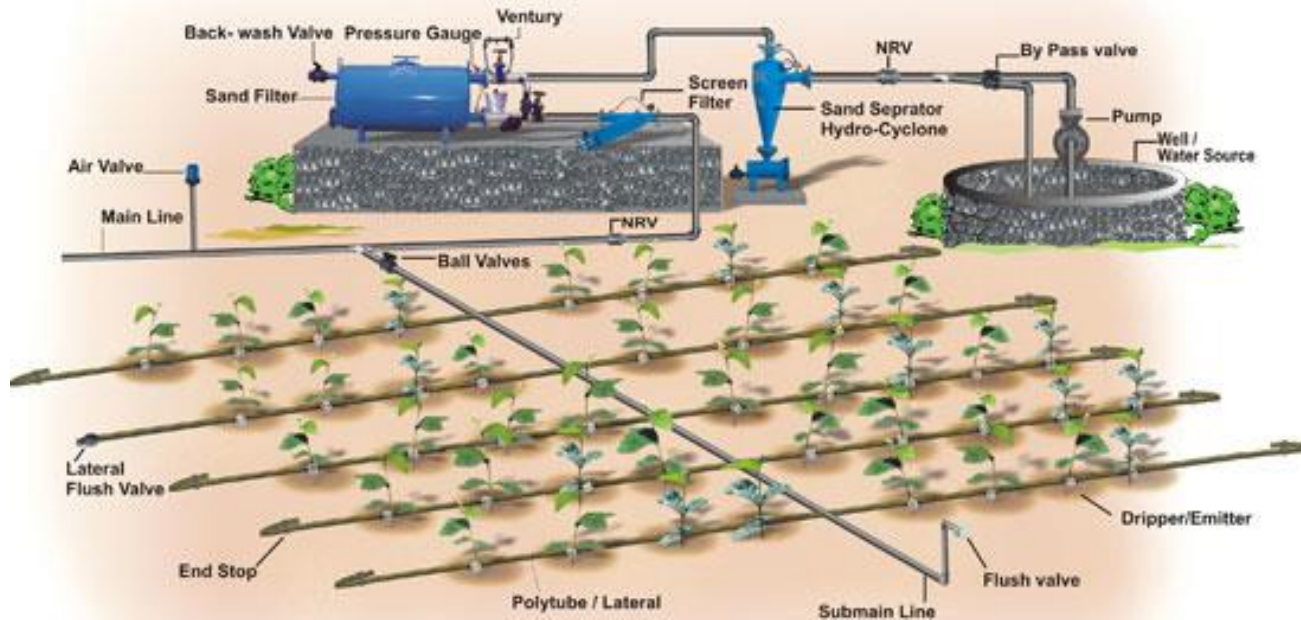
proposed by A. Osterwalder



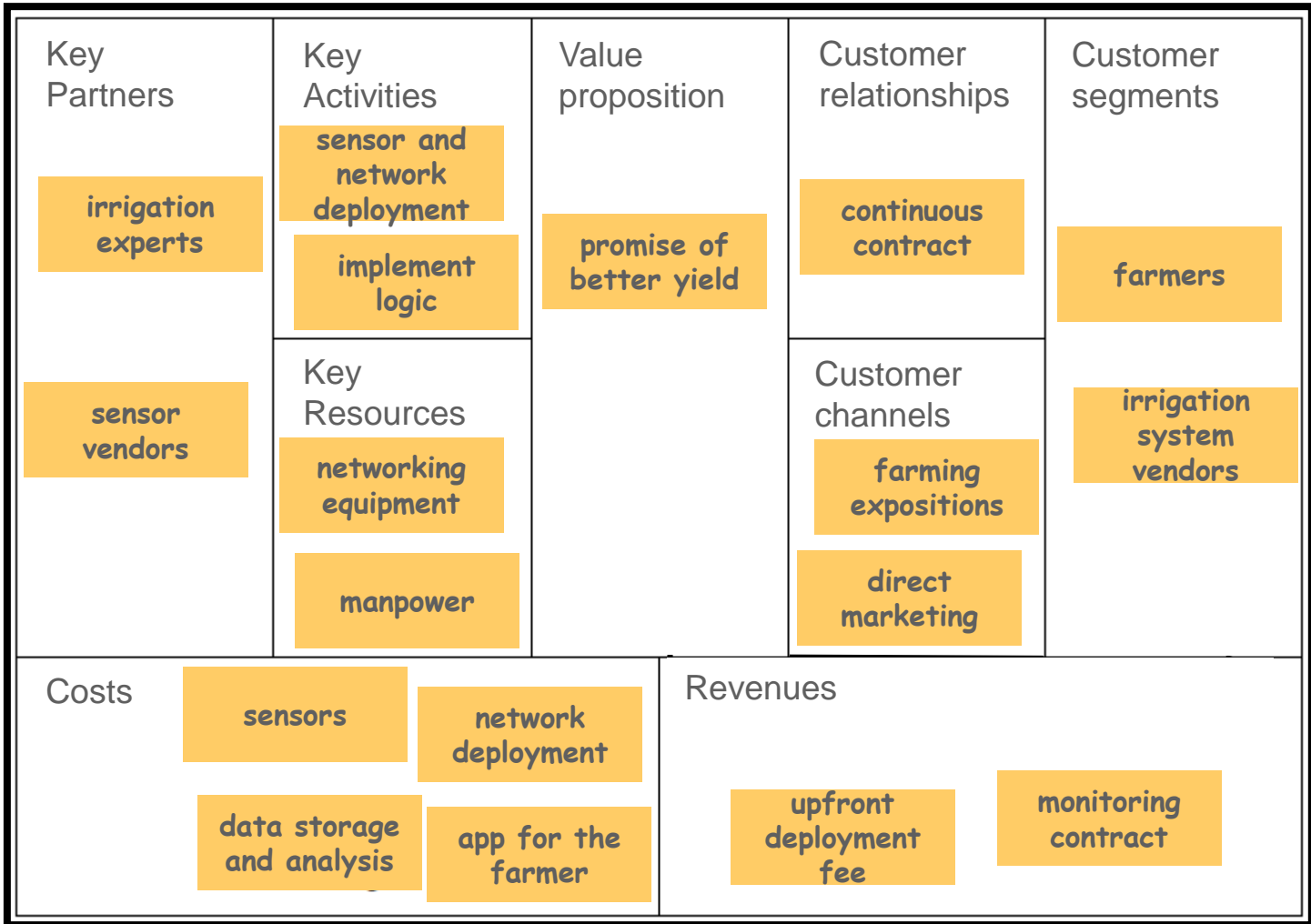
drawings by JAM

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

Designed for:

Designed by:

Date:

Version:

The Business Model Canvas

<p>Key Partners </p> <p>Who are our Key Partners? Who are our key suppliers? Which Key Resources are we acquiring from partners? Which Key Activities do partners perform?</p> <p>KEY PARTNERSHIP ACTIVITIES Distribution and assembly Procurement of raw materials Integration of partner resources and activities</p>	<p>Key Activities </p> <p>What key activities do our Value Propositions require? Our Distribution Channels? Customer Relationships? Revenue streams?</p> <p>KEY ACTIVITIES Manufacturing Product design Human resources</p>	<p>Value Propositions </p> <p>What value do we deliver to the customer? Which one of our customer's problems are we helping to solve? What bundles of products and services are we offering to each Customer Segment? Which customer needs are we satisfying?</p> <p>VALUE PROPOSITIONS Performance Reliability Customization Being the first to market Price Risk reduction Convenience Self-Service Risk Reduction Self-Service Flexibility Personalization/Customization</p>	<p>Customer Relationships </p> <p>What type of relationship does each of our Customer Segments expect us to establish and maintain with them? Which ones have we established? How are they integrated with the rest of our Business Model? How costly are they?</p> <p>CUSTOMER RELATIONSHIPS Self-Service Personalized Automated Personal Assistance Self-Service Automated Services Community Co-creation</p>	<p>Customer Segments </p> <p>For whom are we creating value? Who are our most important customers?</p> <p>KEY SEGMENTS Mass Segment Niche Segment Discounter New Value Network</p>	
<p>Key Resources </p> <p>What Key Resources do our Value Propositions require? Our Distribution Channels? Customer Relationships? Revenue Streams?</p> <p>KEY RESOURCES Channels Customer brand elements (logos, design, names) Human</p>		<p>Channels </p> <p>Through which Channels do our Customer Segments want to be reached? How are we reaching them now? How are we planning to reach them? How are our Channels integrated? Which ones are best? Which ones are most cost-efficient? How are we integrating them with customer touchpoints?</p> <p>CHANNEL STRATEGIES 1. Awareness 2. Evaluation 3. Purchase 4. Post-purchase 5. Retention 6. Advocacy</p> <p>1. Awareness: How do we first communicate about our company's products and services? 2. Evaluation: How are we helping customers evaluate our organization's Value Proposition? 3. Purchase: How do we allow customers to purchase specific products and services? 4. Post-purchase: How are we ensuring a better experience in customers? 5. Retention: How do we provide post-purchase customer support?</p>		<p>Cost Structure </p> <p>What are the most important costs inherent in our business model? Which Key Resources are most expensive? Which Key Activities are most expensive?</p> <p>KEY COST STRUCTURES Our Customer Segment's (B2B) activities for price-value proposition, maximum automation, extensive outsourcing Highly Customized (B2C) or value-oriented, extensive value proposition Highly Customized (B2C) or value-oriented, extensive value proposition</p> <p>KEY COST STRUCTURES Fixed costs (salaries, rent, utilities) Variable costs Semi-variable costs Economies of scale</p>	<p>Revenue Streams </p> <p>For what value are our customers really willing to pay? For what do they currently pay? How are they currently paying? How should they prefer to pay? How much does each Revenue Stream contribute to overall revenues?</p> <p>REVENUE STREAMS Asset Sale Usage Fee Subscription Fee Licensing Advertising Rental Leasing Performance-based Transaction Fee Freemium Usage Fee Subscription Fee Licensing Advertising Rental Leasing Performance-based Transaction Fee Freemium</p>

DESIGNED BY: Business Model Foundry AG
The makers of Business Model Generation and Strategyzer

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Strategyzer

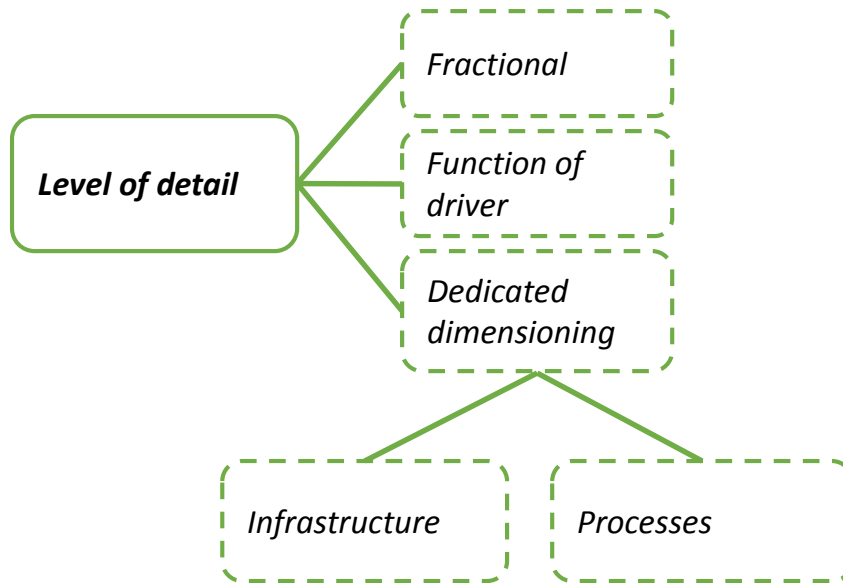
strategyzer.com

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

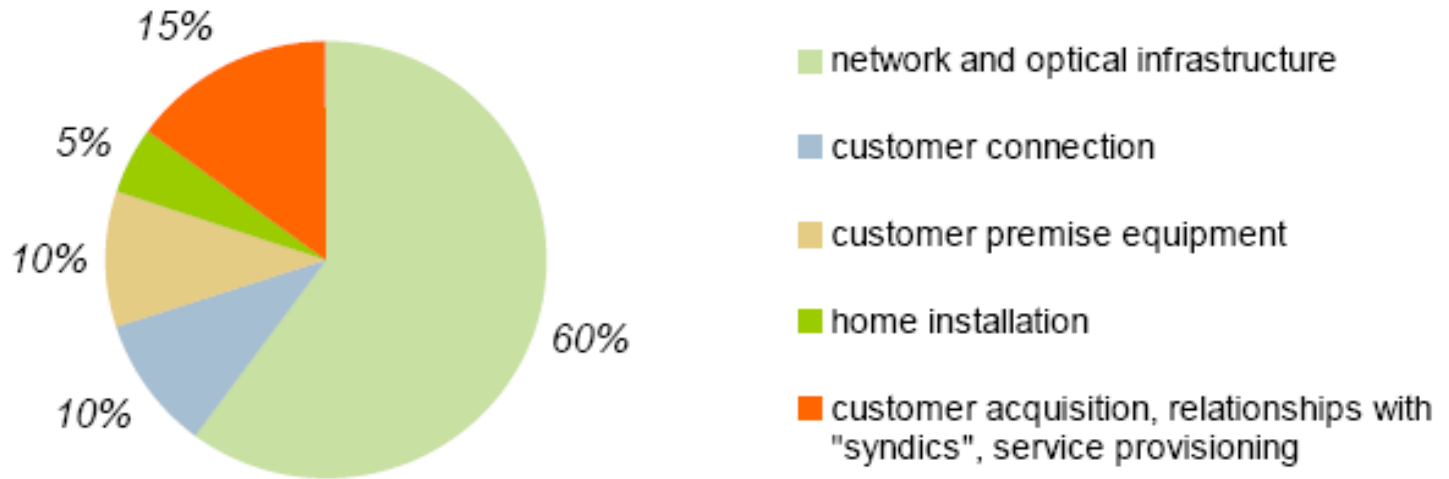
Appropriate level of detail/abstraction

depends on available input data and goal of the model



Fractional cost modeling is on the highest abstraction level

cost structure derived from pilot phase



for a 10% penetration rate (subscribers / home passed)

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)

...

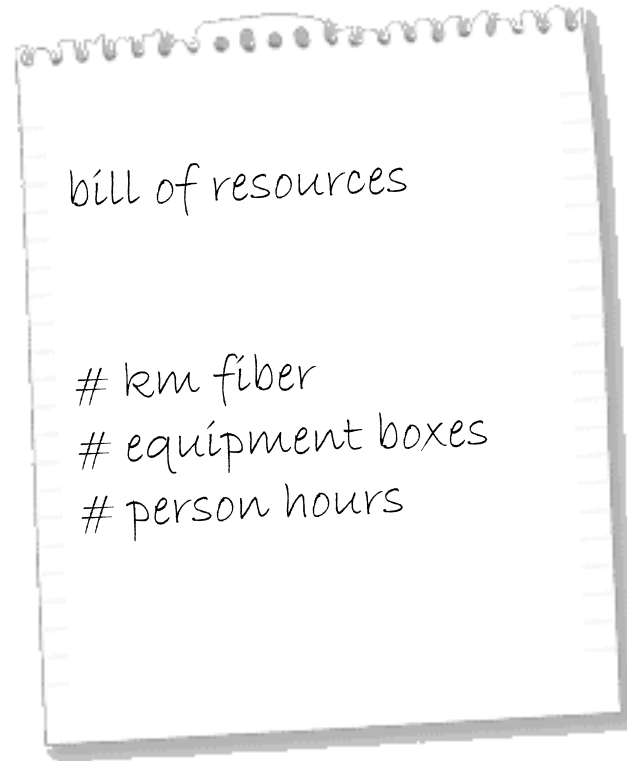
→ combinations possible

Find the parameter that mainly drives the cost

This is the most common cost modeling approach!

Dedicated dimensioning

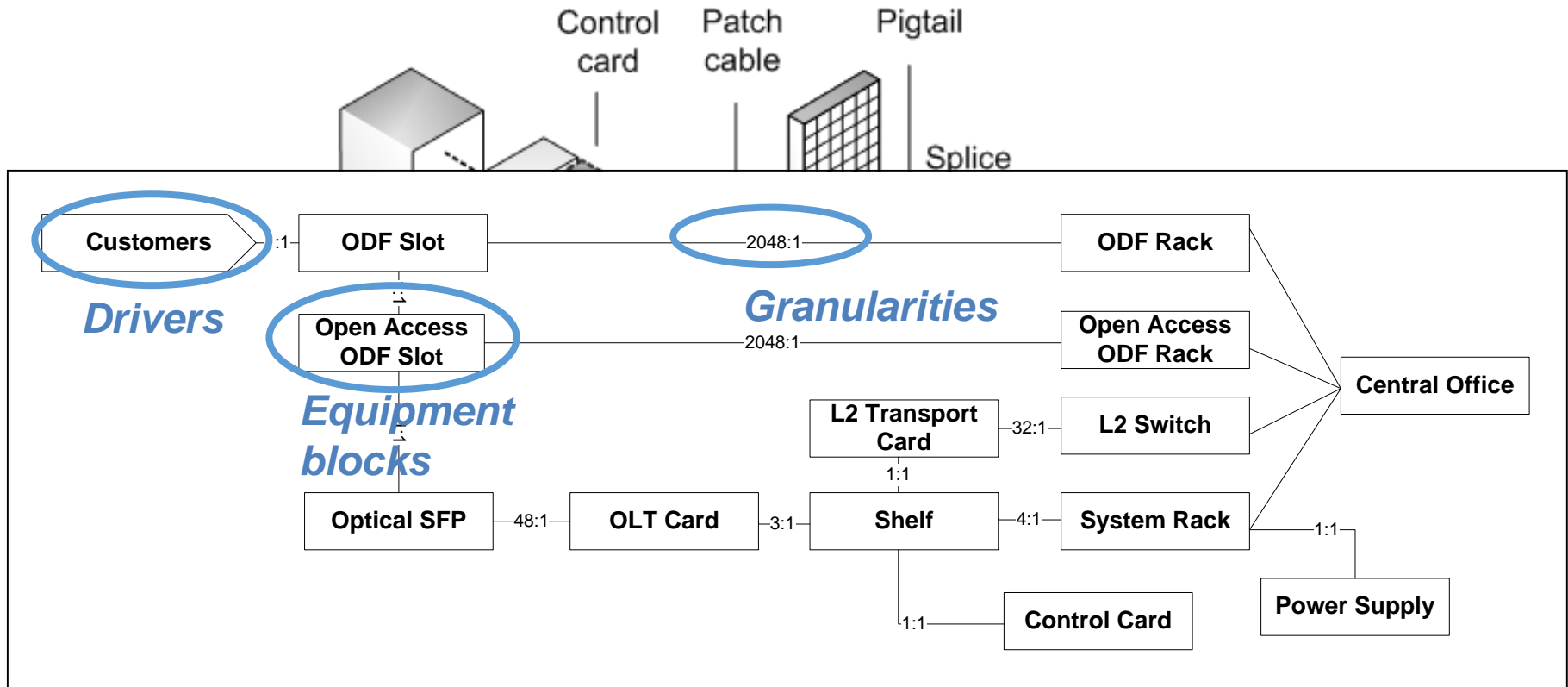
is on the lowest abstraction level, thus gives most detail



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

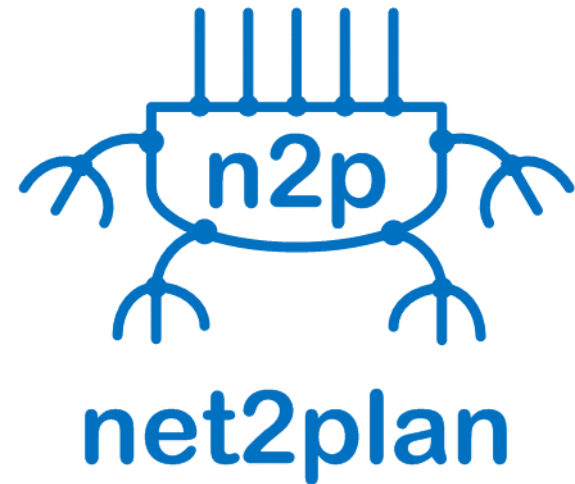
Open Specification for
Equipment Coupling Modeling Notation
(ECMN)

developed by iMinds

Net2Plan tool available

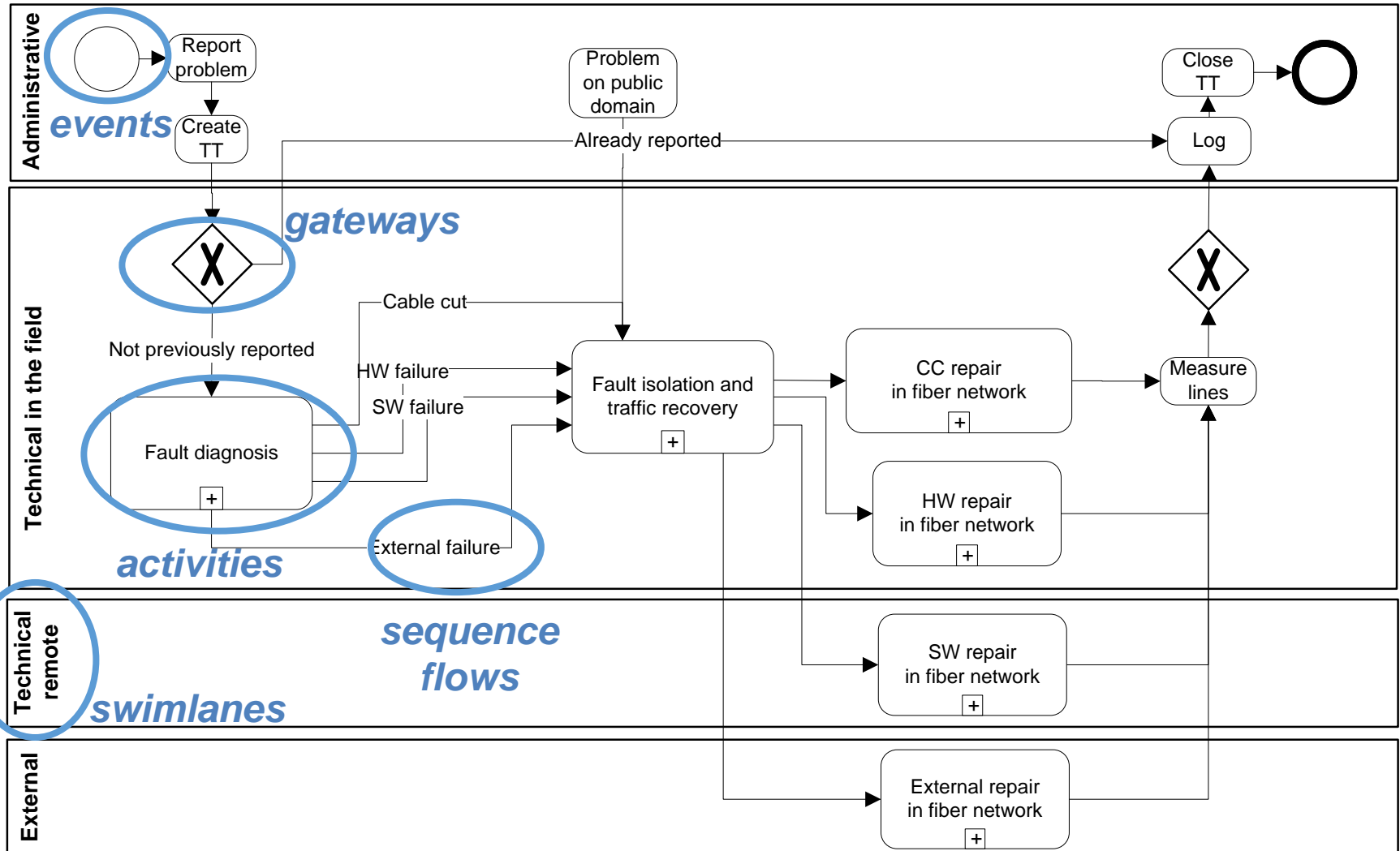
allows to model equipment per year

- 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



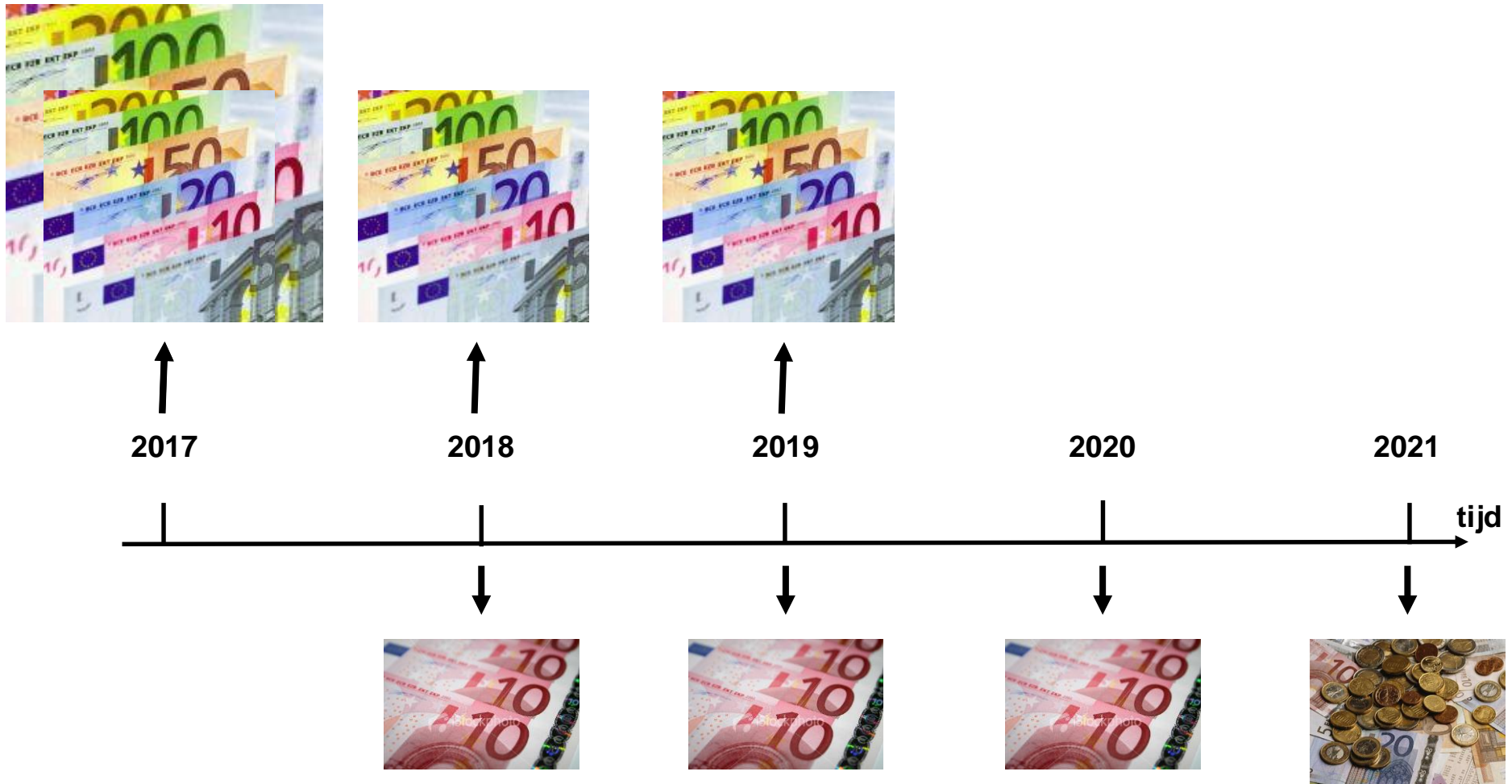
Detailed process modeling using BPMN

example: network repair process



Investment decision

is about comparing incoming and outgoing cash-flows over time

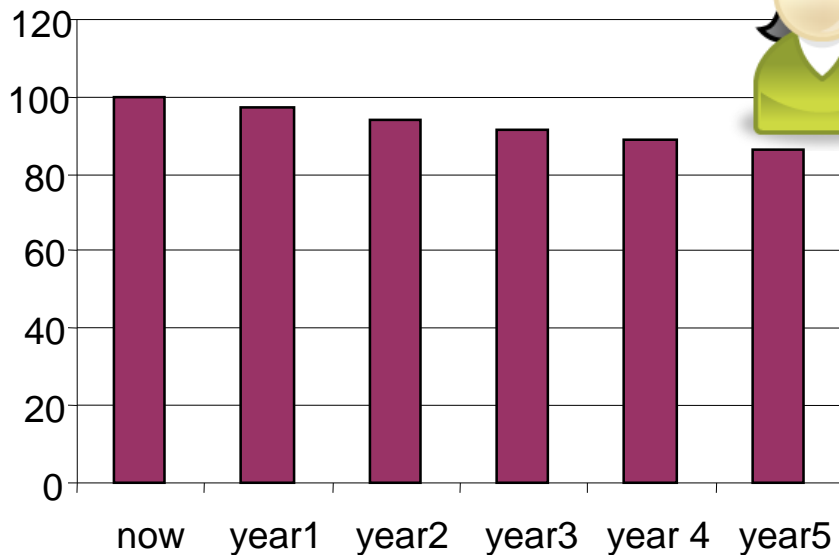


Net present value

is widely spread investment decision technique



current value of 100€ spent in the future

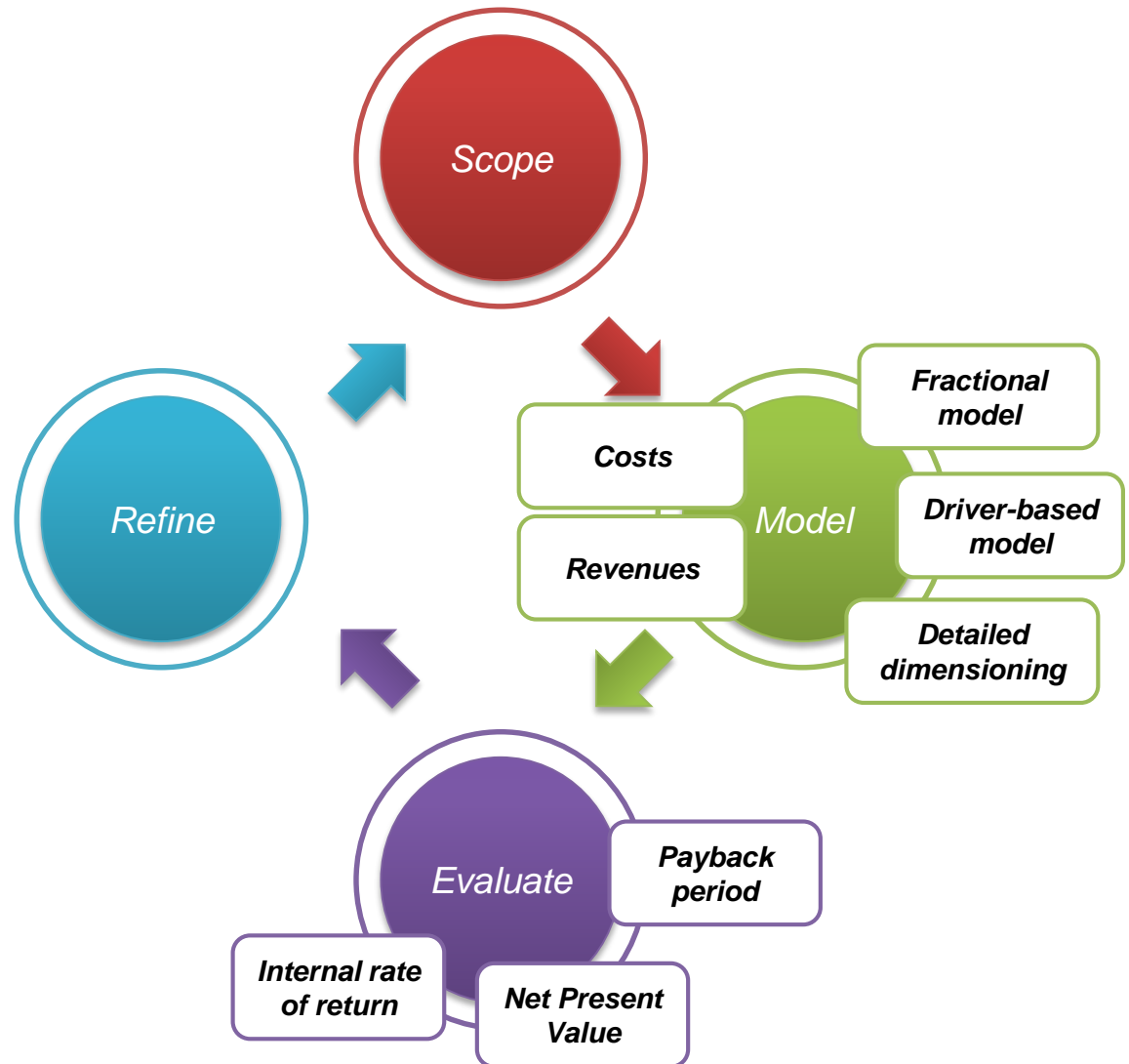


(r = 3%)

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

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

White paper and tutorial available for techno-economic analysis cycle

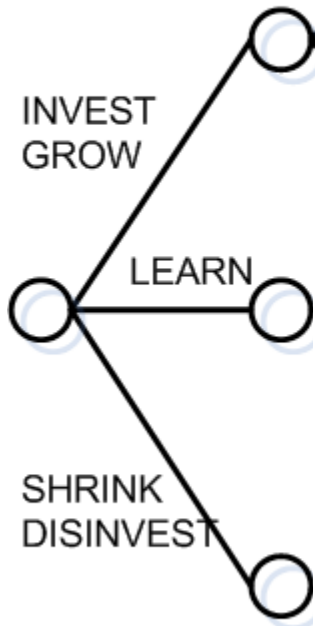


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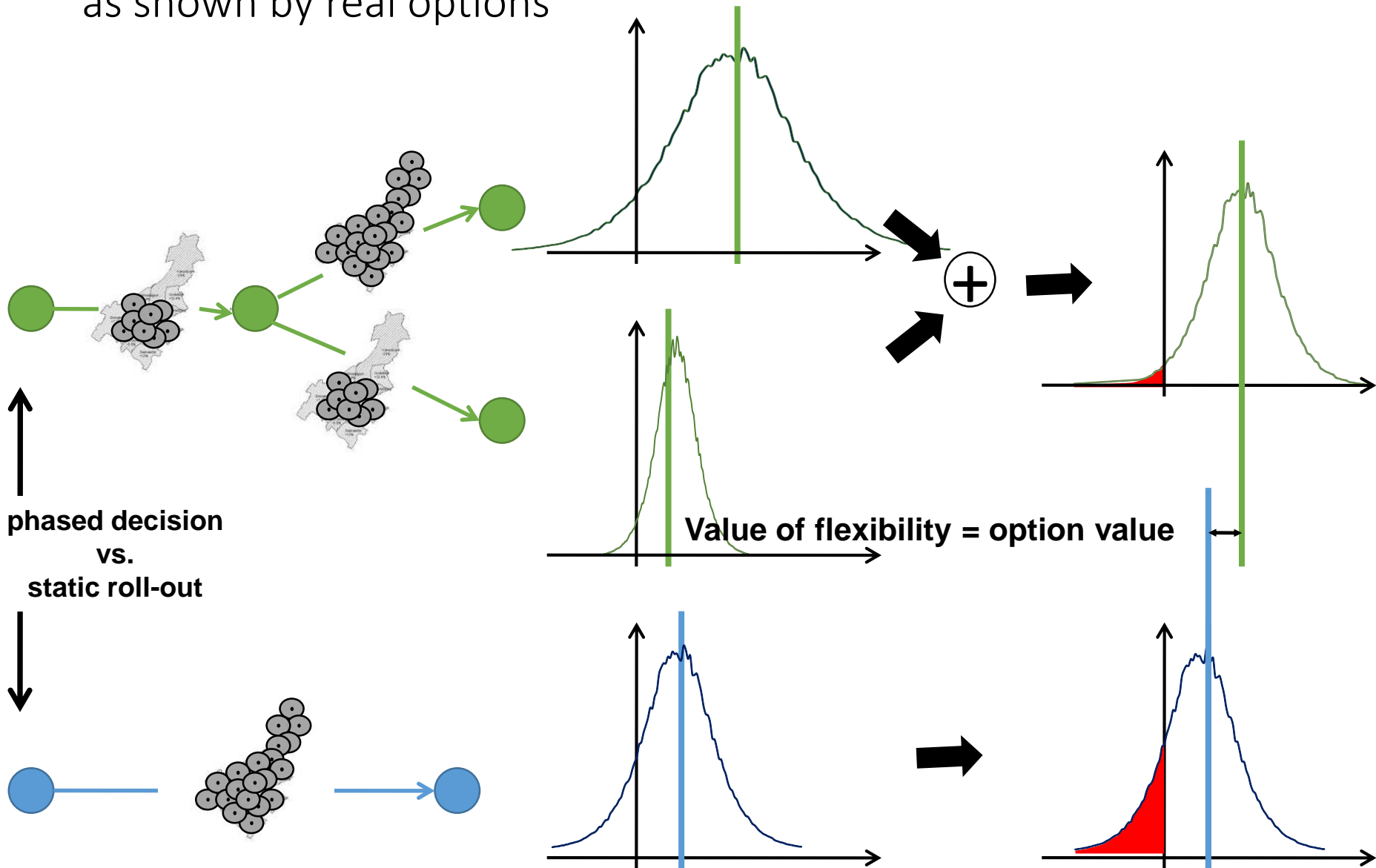
Real option theory

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



Flexible roll-out gives value

as shown by real options



Tutorial paper and presentation available concerning practical use of real options in ICT projects

1

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*

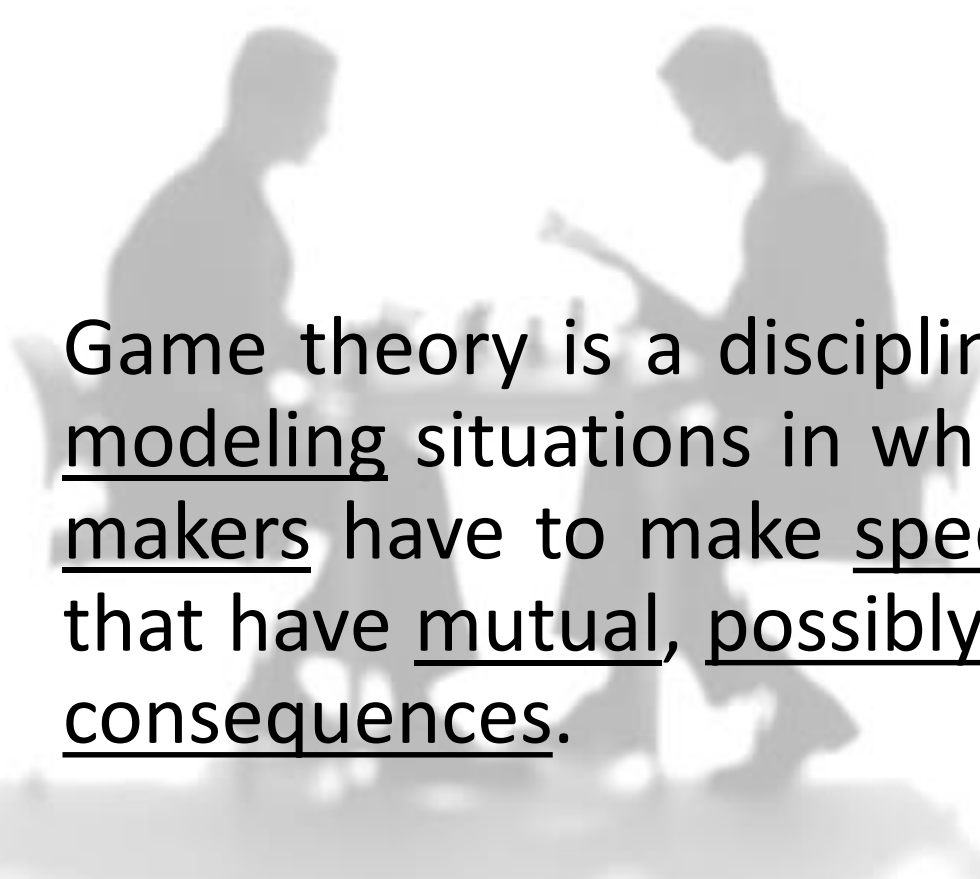
Abstract—The rapid technological change and uncertain future evolutions have a large impact on investment projects in the telecommunication sector. When new infrastructure networks are rolled out, the initial assumptions can prove to be untrue in the future, severely impacting the payoff. It is therefore 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

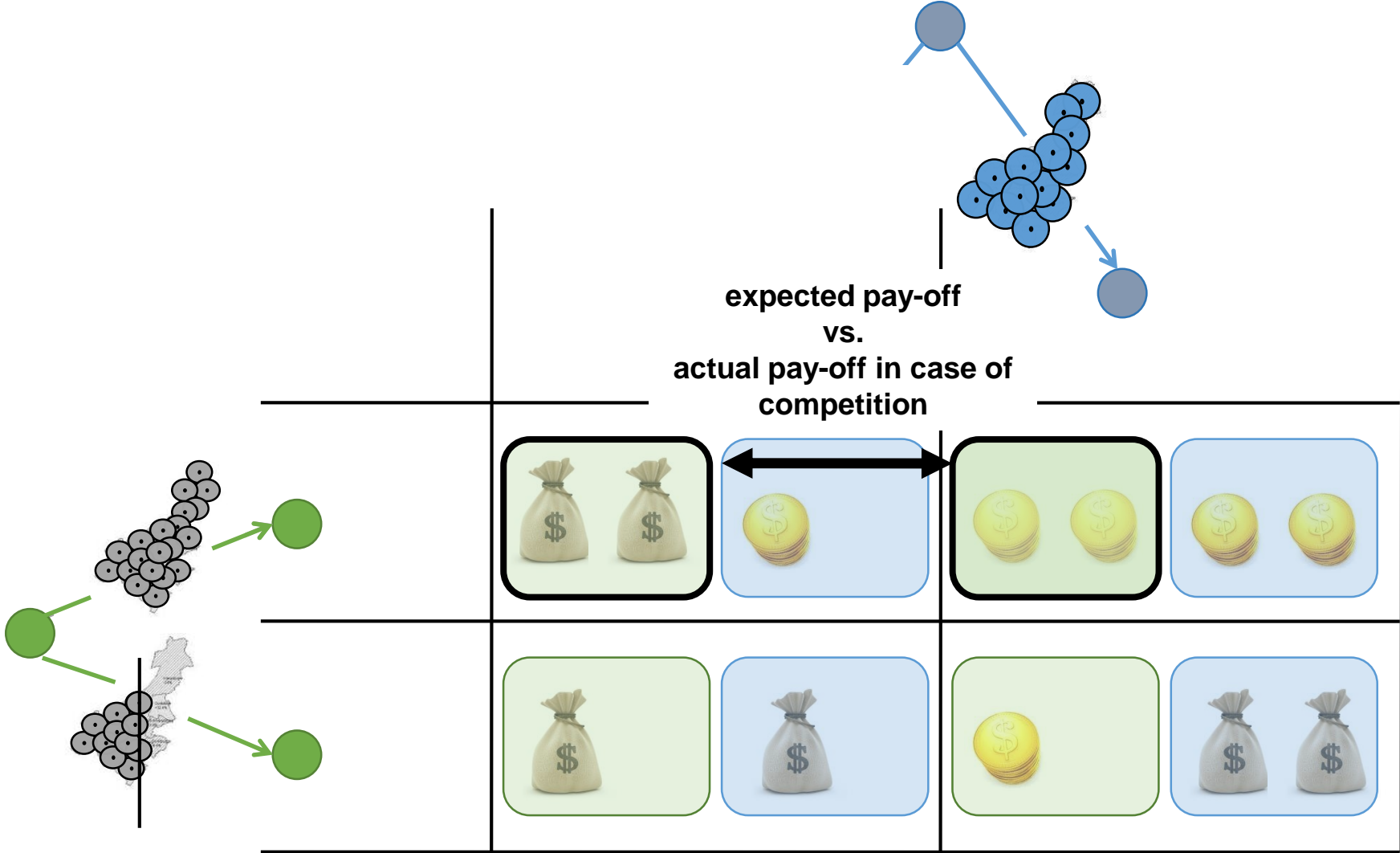
models the impact of interaction



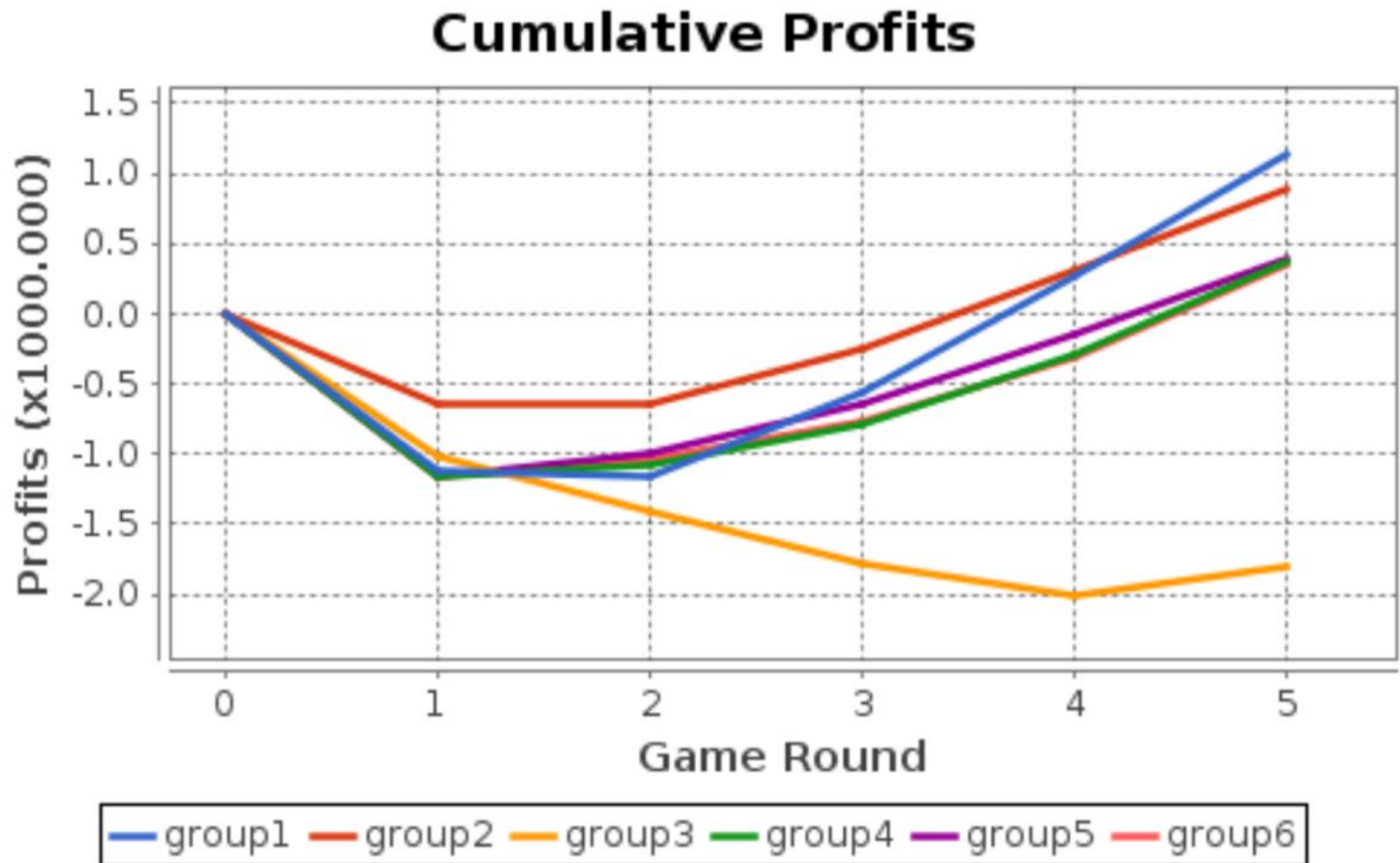
Game theory is a discipline aimed at modeling situations in which decision makers have to make specific actions that have mutual, possibly conflicting, consequences.

Competition has big impact

as shown by game theory

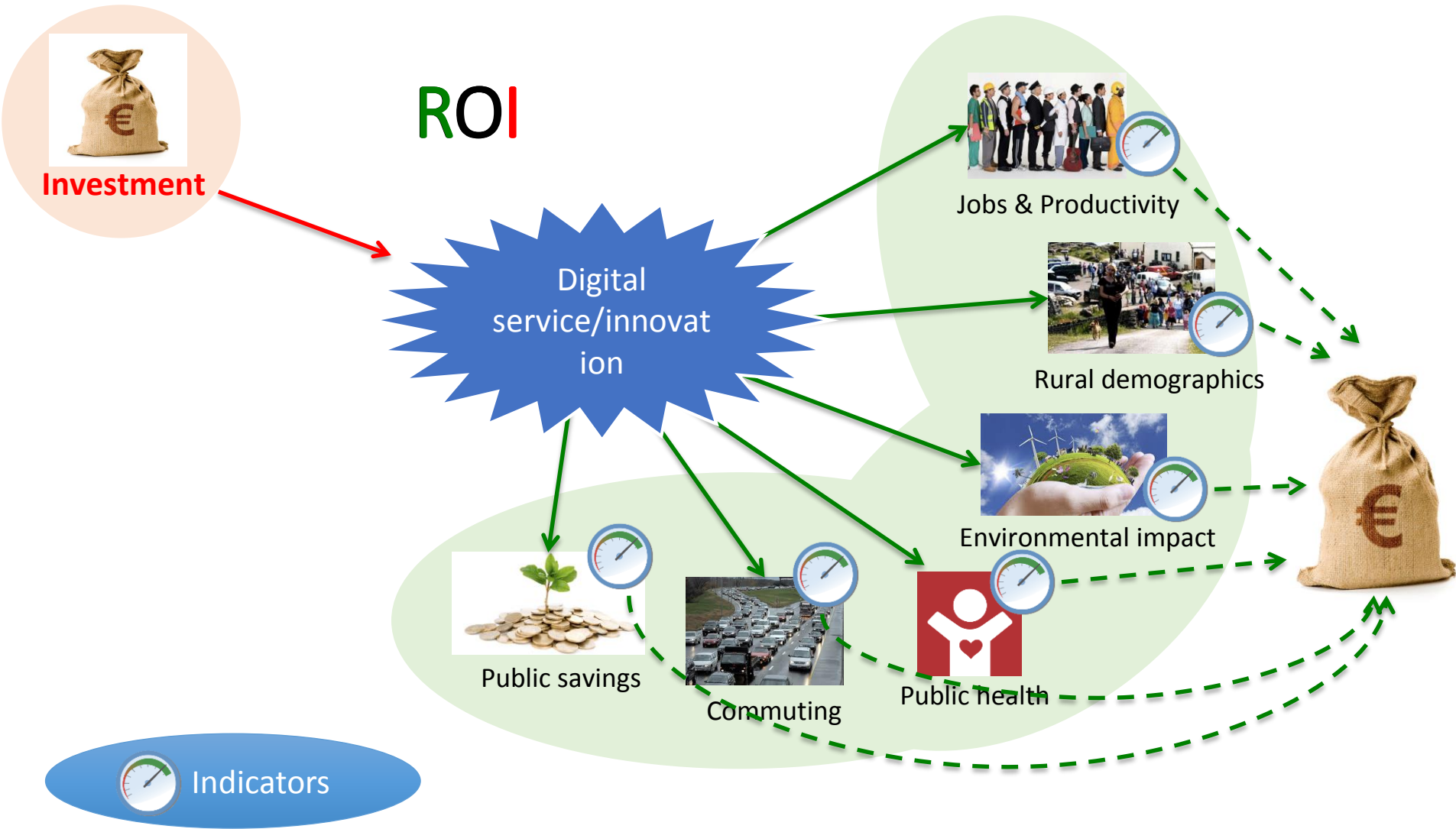


Online business game available for integration in Master course



Indirect effects can be modeled

by socio-economic return on investment indicators (SEROI)



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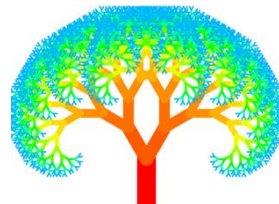


**TEMPLATES &
DATA**



EVENTS

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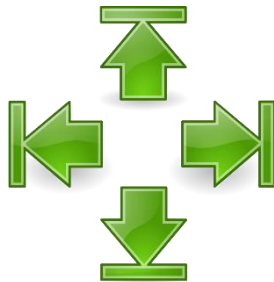
Standard approaches can help in order to tackle difficulties in techno-economic research



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

International Conference on Design of Reliable Communication Networks 2017

8-10 March 2017, Munich, Germany



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



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

Conference Dinner



Friday, March 10

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

Keynote 2



[Multi-layer resilience schemes and their control plane support](#)

Victor Lopez (Telefonica, Spain)

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

Coffee Break



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

Invited Talk Session 4



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

Session 4 - Disaster



[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 Zeglache (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)

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