

# ***Network infrastructure as a common-pool resource***

Community networks: [guifi.net](http://guifi.net)

Roger Baig Viñas

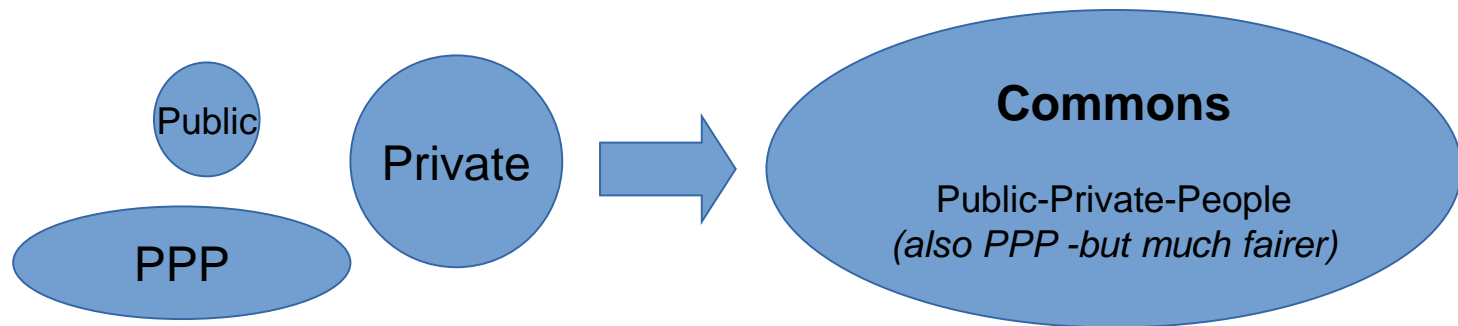
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# Background

- What is Internet?
  - “C’mon, I know, ‘the network of networks’”
- How do networks interconnect?
  - Peering (IXPs) vs. transit (NSPs)
  - Tiers
- Which is the general structure of Internet?
  - Backbone, middle-mile, last-mile
- Who builds Internet? Who owns it? Who makes it work (operate)?
  - The States? The ISPs?
  - Who are the ISPs?
  - (Hint: in Western Countries the sector is liberalised)
    - *Liberalised?*

# Infrastructure models

- Dominant models
  - Public sector
  - Public-private partnerships (PPP)
  - Private sector
- As we see it:



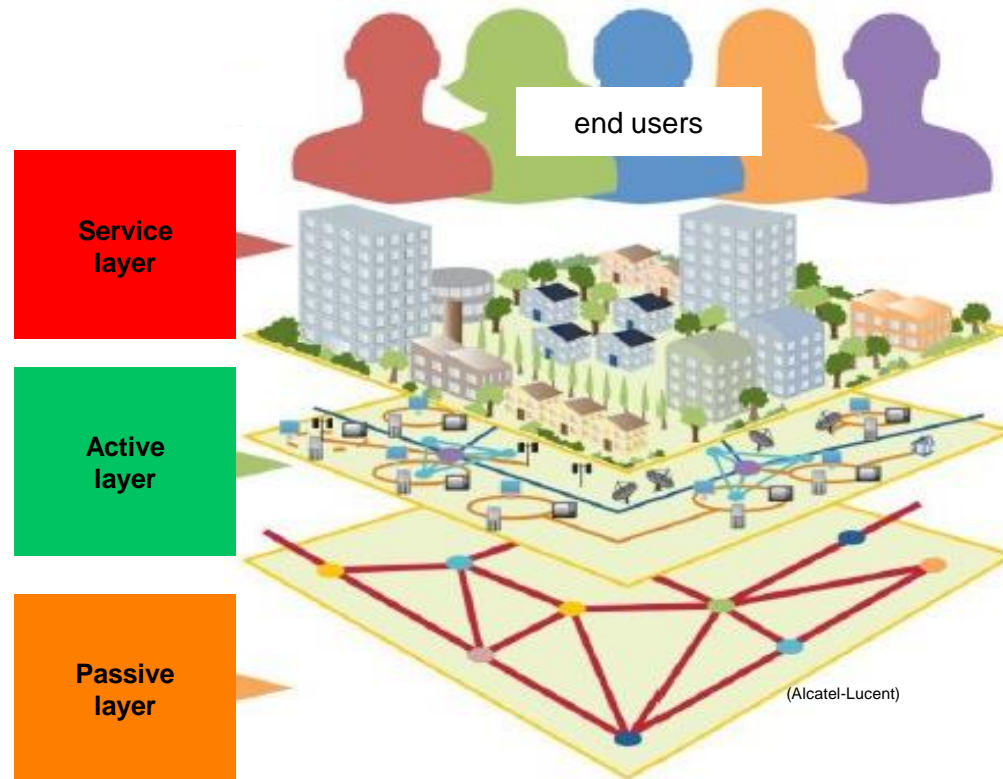
# ***Infrastructure & the commons***

- B. Frischman [4]
  - Infrastructure: “a particular set of resources defined in terms of the manner in which they create value”
  - Commons: “a resource management principle by which a resource is shared within a community ... on nondiscriminatory terms”
- B. Harding [2]
  - “The tragedy of the commons” **OMG!!!**
- E. Ostrom [3]
  - “The 8 desing principles for long-enduring CPRs” **Hooray!!!**

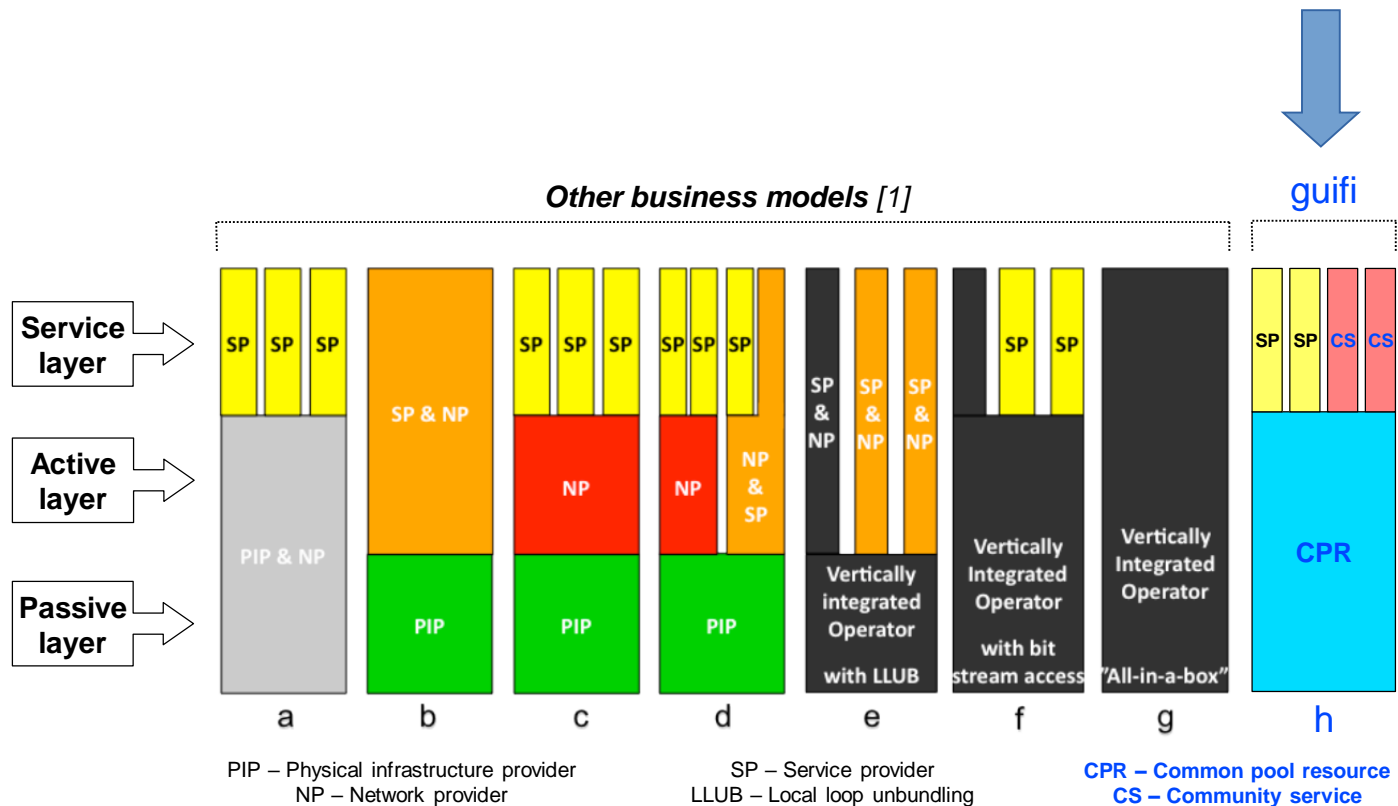
# Commons vs. private-driven

|                   | Guifi.net  | Private sector   |
|-------------------|--|--|
| <b>Objective</b>  | Maximisation of the size and use of the shared good (social benefit) | Maximisation of the profit of the investors                                  |
| <b>Manages</b>    | Common-pool resources  | Private goods & exclusive rights   |
| <b>Strategy</b>   | Optimisation of cooperation  | Maximisation of the market-share (become a monopoly, ideally)                |
| <b>Investment</b> | Long-term, collective  | Short-term, speculative  |
| <b>Governance</b> | Self-governance, self-regulation                                     | Needs external legislation and regulation                                    |
| <b>Features</b>   | Cost-oriented, inclusive, sustainable, redistributive, local         | Directional pricing, extractive, market failures, speculative, transnational |

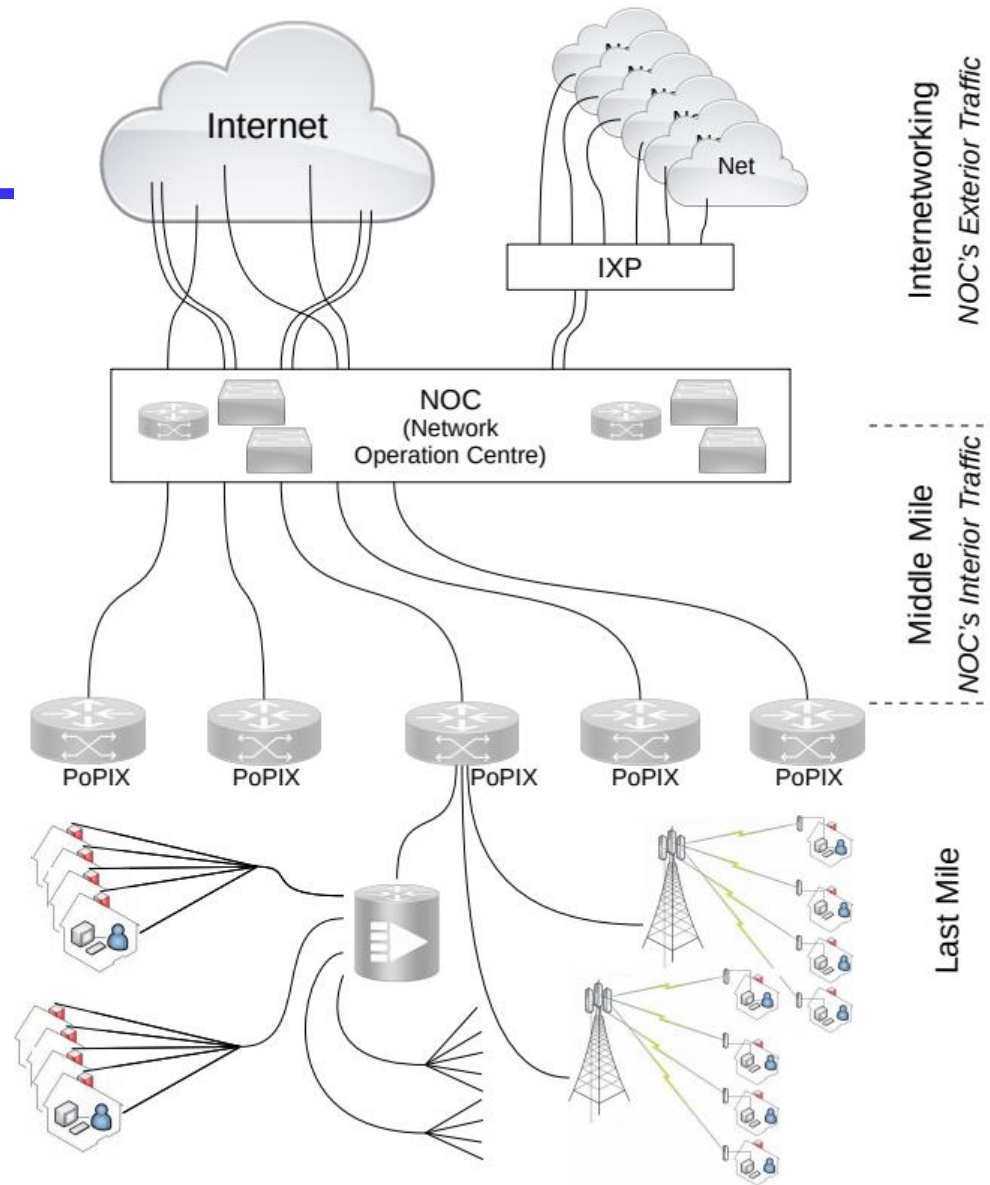
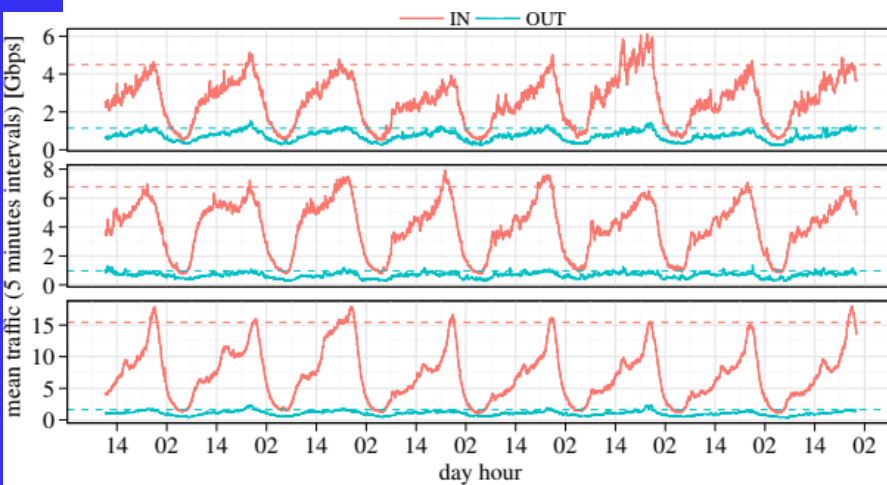
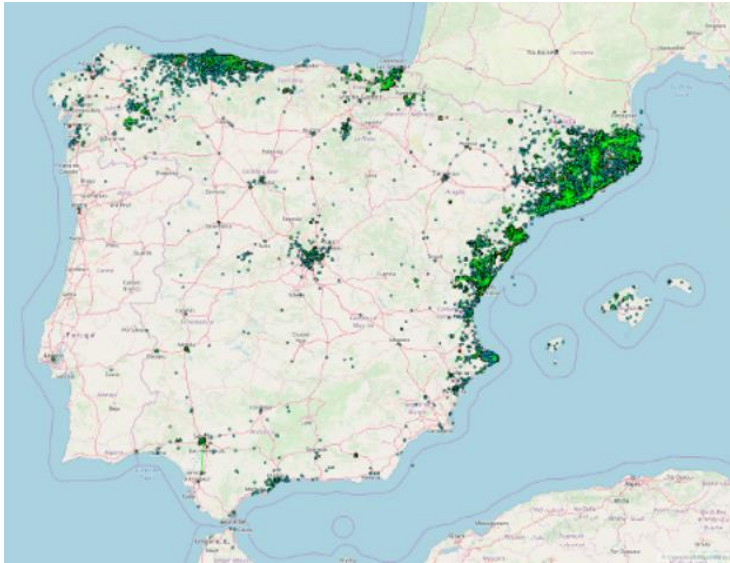
# ***Infrastructure (network) layers***



# Business models

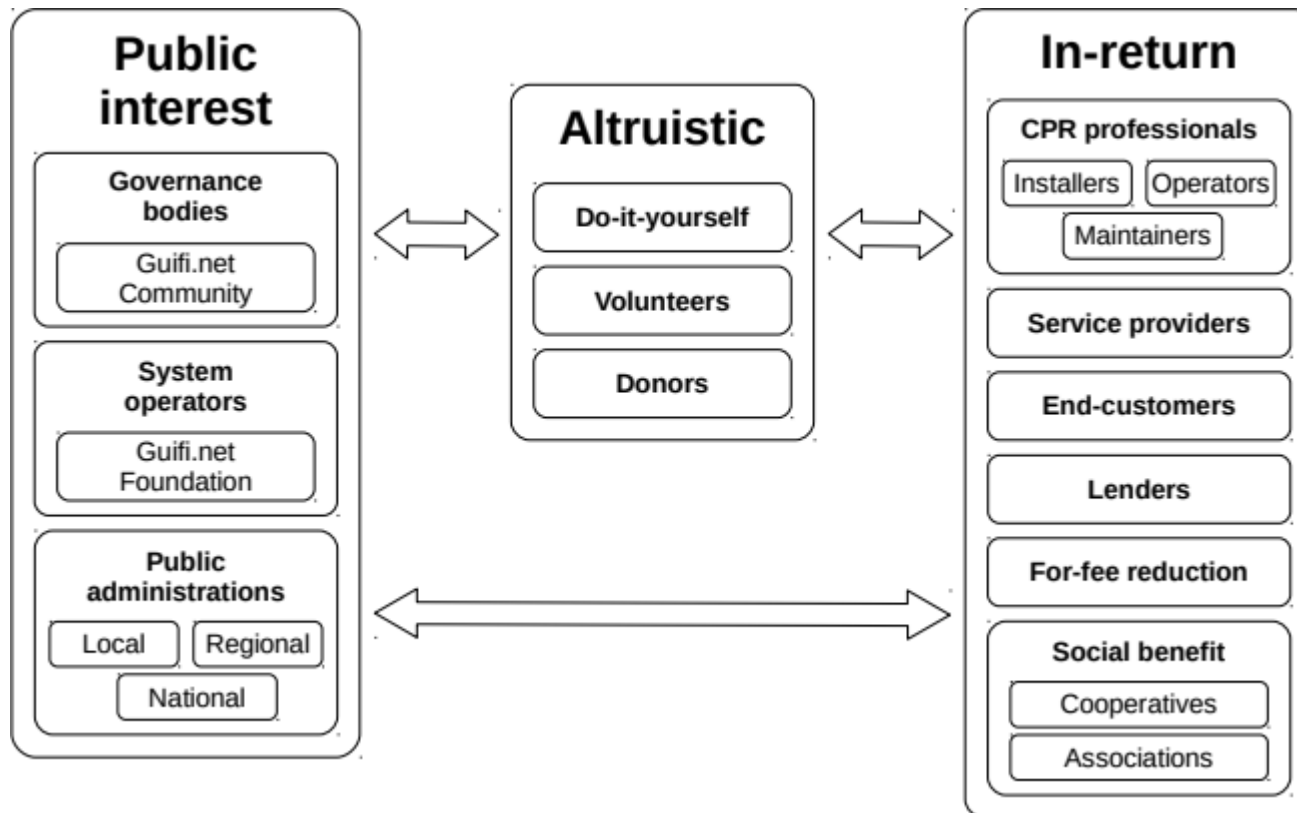


# Success indicators

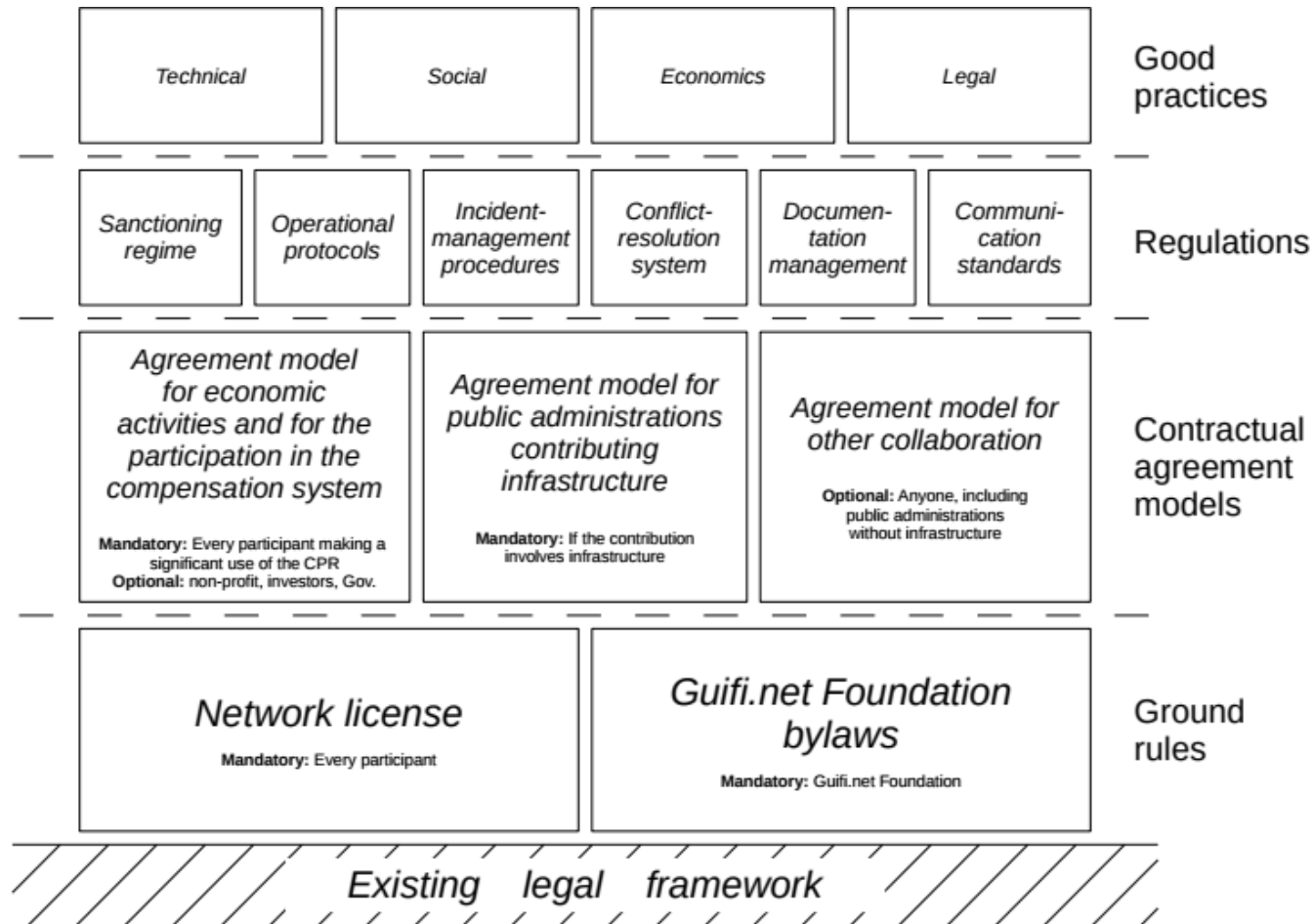




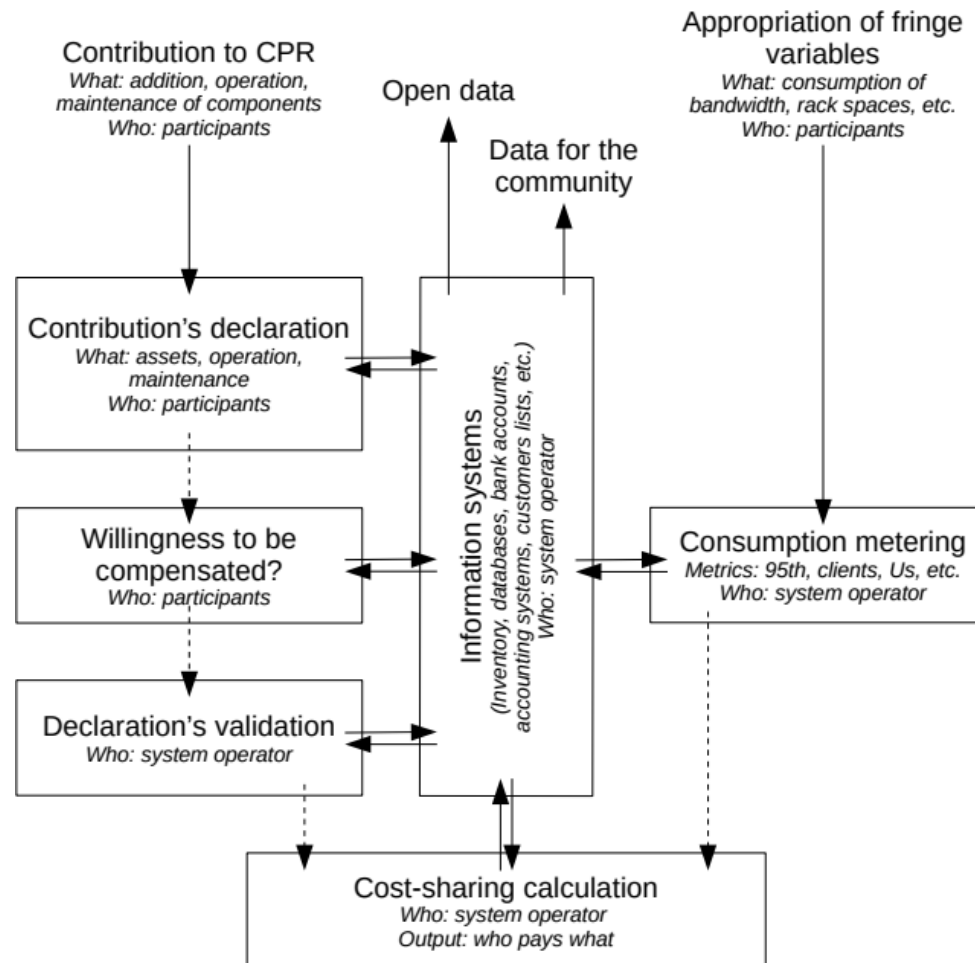
# Stakeholders



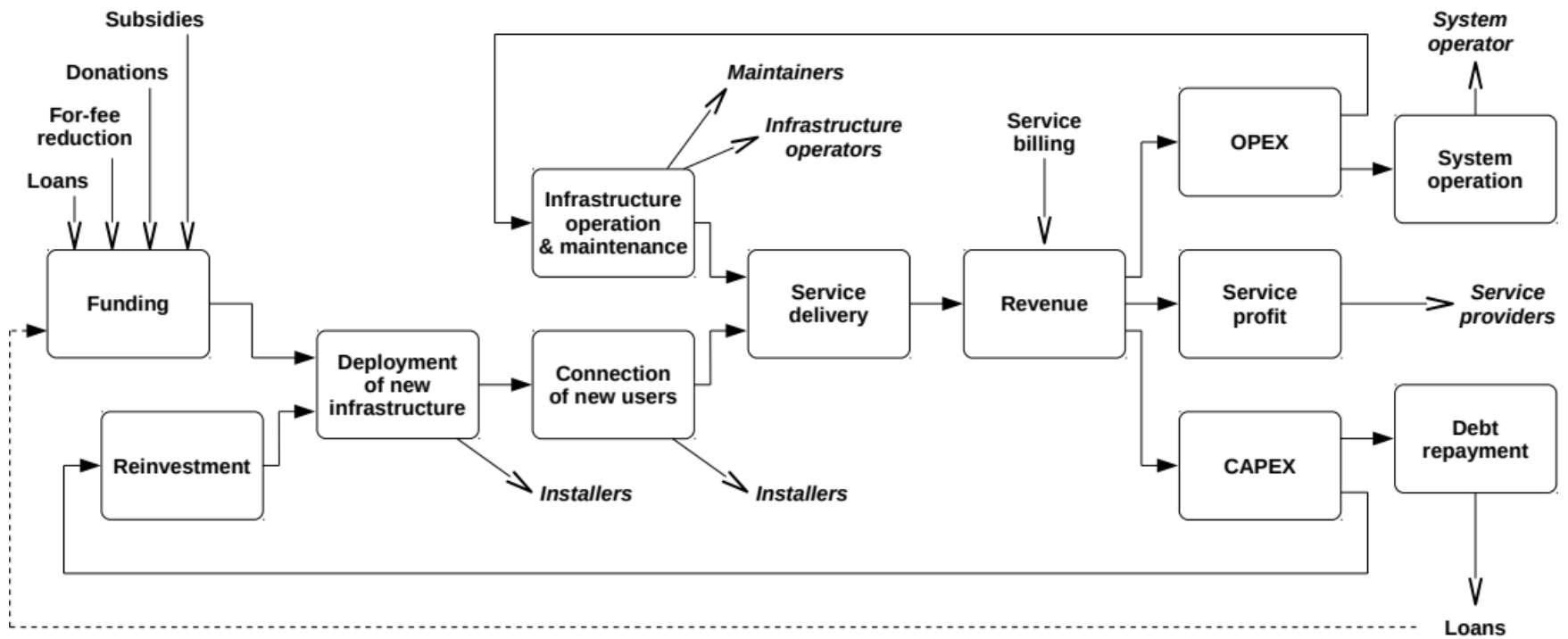
# Internal regulation



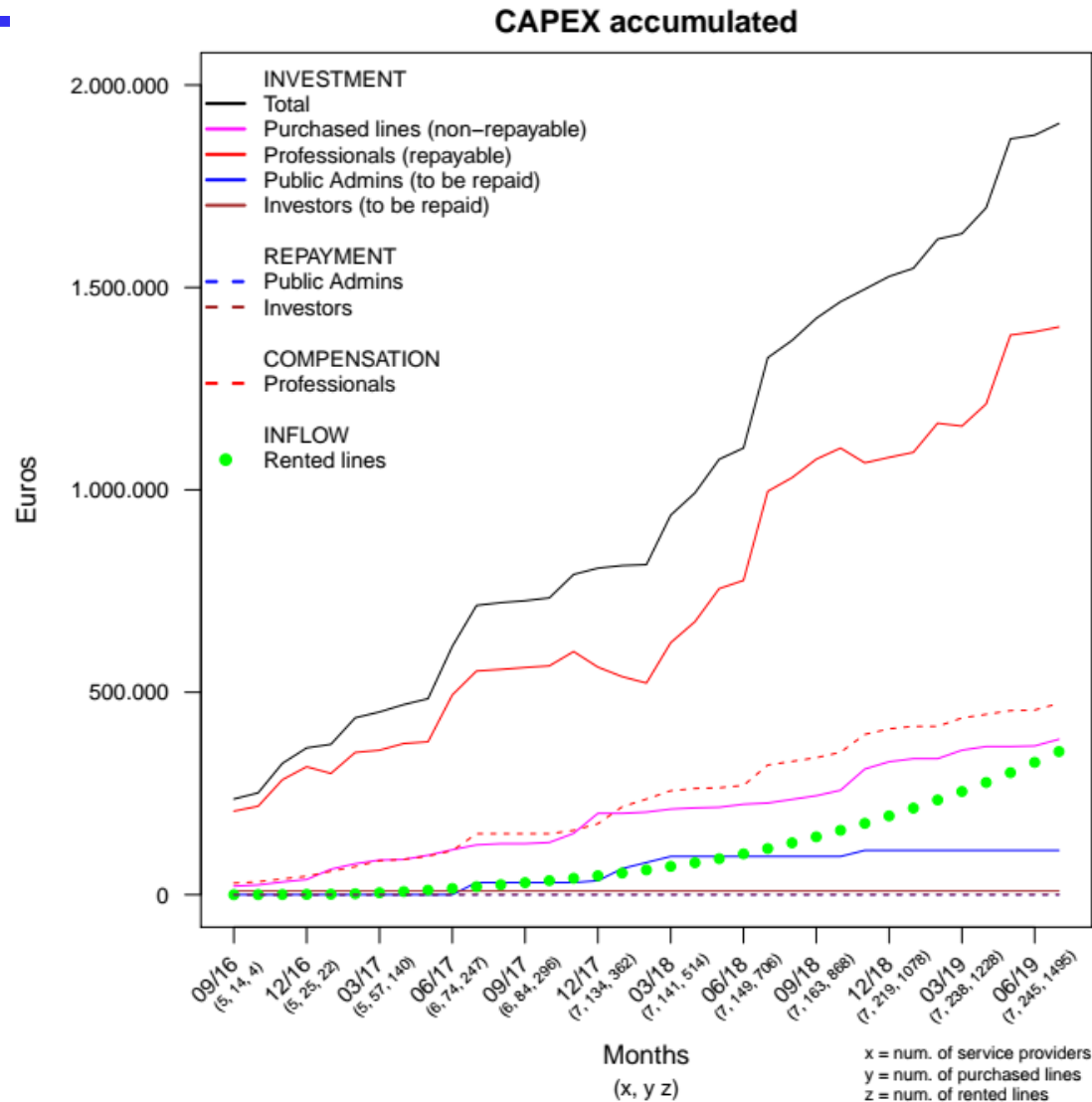
# Cost-compensation system



# Financial flows



# Example of CAPEX



# Evolution over time

| YEAR                  | 2004   | 2005   | 2006   | 2007   | 2008  | 2009  | 2010  | 2011   | 2012  | 2013   | 2014   | 2015  | 2016   | 2017  | 2018  | 2019  |  |   |   |   |  |   |   |   |   |   |   |   |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |
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| FACTS                 | <b>PROJECT INCEPTION</b> <ul style="list-style-type: none"><li>Volunteers</li><li>Community empowerment</li><li>WiFi technology</li></ul>  |  |  | <b>WEBSITE</b> <ul style="list-style-type: none"><li>Maps</li><li>Unsolclic (HW auto-conf)</li></ul> | <b>WEBSITE</b> <ul style="list-style-type: none"><li>Crowdfunding</li></ul> | <b>BAD PRACTICES</b> <ul style="list-style-type: none"><li>Some SMEs working below expectations</li><li>Bad reputation for the whole project</li></ul> <b>PROFESSIONAL AGREEMENTS</b> <ul style="list-style-type: none"><li>Formalisation of duties to pursue a professional activity</li></ul> | <b>WEBSITE</b> <ul style="list-style-type: none"><li>Crowdfunding</li></ul> | <b>INTERNET CONNECTION</b> <ul style="list-style-type: none"><li>Carrier house, wholesale Internet</li><li>gLR working group</li></ul> | <b>REGIONAL BACKHAUL</b> <ul style="list-style-type: none"><li>Fibre optic rental</li><li>PoPIX</li></ul> <b>ISPs: LACK OF COOPERATION</b> <ul style="list-style-type: none"><li>Not pooling services due to lack of collaborative tools and habits</li></ul> <b>COST-COMPENSATION SYSTEM</b> <ul style="list-style-type: none"><li>At carrier house</li><li>Cost oriented</li><li>Costs shared according to resource usage</li></ul> | <b>COMPENSAT. SYS.</b> <ul style="list-style-type: none"><li>System activation</li><li>Two initial zones</li></ul> <b>ISPs: TRADE WAR, CARTELS, ETC.</b> <ul style="list-style-type: none"><li>Poor reporting</li><li>Lack of transparency</li><li>Private deployments</li></ul> <b>CONFLICT-RESOLUTION SYS.</b> <ul style="list-style-type: none"><li>Development</li><li>Activation</li></ul> <b>SANCTIONING REGIME</b> <ul style="list-style-type: none"><li>Development</li><li>Activation</li></ul> | <b>COMPENSAT. SYS.</b> <ul style="list-style-type: none"><li>Two more zones added</li><li>Dissemination to other zones</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: JOINT LOBBY</b> <ul style="list-style-type: none"><li>Complaint about the cost-compensation syst. efficiency</li><li>Attempt to impose radical changes under threats of massive abandonment of the system</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> |  |   |   |   |  |   |   |   |   |   |   |   |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |
|                       | <b>FIRST PUBLIC ADMs</b> <ul style="list-style-type: none"><li>Village councils to fight lack of Internet</li><li>Local public funds for supernodes</li><li>Internet via proxy connected to precarious DSLs</li></ul> <b>ISPs: INITIAL ECONOMIC ACTIVITY</b> <ul style="list-style-type: none"><li>Local SMEs to carry out Councils' projects and to connect end-users</li><li>Initial Internet access delivered by ISPs as a service (using DSLs)</li></ul> | <b>LEGAL REQUIREMENTS</b> <ul style="list-style-type: none"><li>Legal requirements (registration at the NRA, etc.)</li><li>Impossibility to access public/private institutions, professional resources, etc.</li></ul> | <b>FOUNDATION</b> <ul style="list-style-type: none"><li>Establishment</li><li>NGO, non-partisan, without conflicts of interest</li></ul> |  |   |   |   |  |   |  |  |   |  |   |   |   | <b>LICENSE</b> <ul style="list-style-type: none"><li>Modification to fulfil legal requirements</li></ul> | <b>LICENSE</b> <ul style="list-style-type: none"><li>Second version release</li></ul> | <b>ECONOMIC ACTIVITY AGREEMENT</b> <ul style="list-style-type: none"><li>Mandatory for all professionals</li><li>Enforcing participation in the cost-compensation sys.</li><li>Commitment based commons</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: JOINT LOBBY</b> <ul style="list-style-type: none"><li>Complaint about the cost-compensation syst. efficiency</li><li>Attempt to impose radical changes under threats of massive abandonment of the system</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> | <b>ISPs: BREACH OF DUTY AGAIN</b> <ul style="list-style-type: none"><li>Old + new bad practices</li></ul> |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |
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| <b>THREATS/ NEEDS</b> | <b>THREATS/ NEEDS</b>  | <b>THREATS/ NEEDS</b>  | <b>THREATS/ NEEDS</b>  | <b>THREATS/ NEEDS</b>  | <b>THREATS/ NEEDS</b>   | <b>THREATS/ NEEDS</b>   | <b>THREATS/ NEEDS</b>   | <b>THREATS/ NEEDS</b>  | <b>THREATS/ NEEDS</b>   | <b>THREATS/ NEEDS</b>  |  |   |  |   |   |   |  |   |   |   |  |   |   |   |   |   |   |   |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |                       |

# ***Bibliographic references***

[1] M. Forzati, C. P. Larsen, and C. Mattsson. “Open access networks, the Swedish experience”. In: 12th International Conference on Transparent Optical Networks (ICTON). 2010

[2] G. Hardin. “The Tragedy of the Commons”. In: Science 162 (Dec. 1968), pp. 1243–1248.

<http://www.sciencemag.org/cgi/reprint/162/3859/1243.pdf>

[3] E. Ostrom. *Governing the Commons: The Evolution of Institutions for Collective Action. Political Economy of Institutions and Decisions.*

Cambridge University Press, 1990. isbn: 978-0521405997.

[https://wtf.tw/ref/ostrom\\_1990.pdf](https://wtf.tw/ref/ostrom_1990.pdf)

[4] B. M. Frischmann. *Infrastructure: The social value of shared resources.* Oxford University Press, 2012. isbn: 978-0199975501