1st Workshop on Business Models and Techno-Economics of 5G Networks and Beyond
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Business Models for 5G Experimentation as a Service: 5G Testbeds and Beyond

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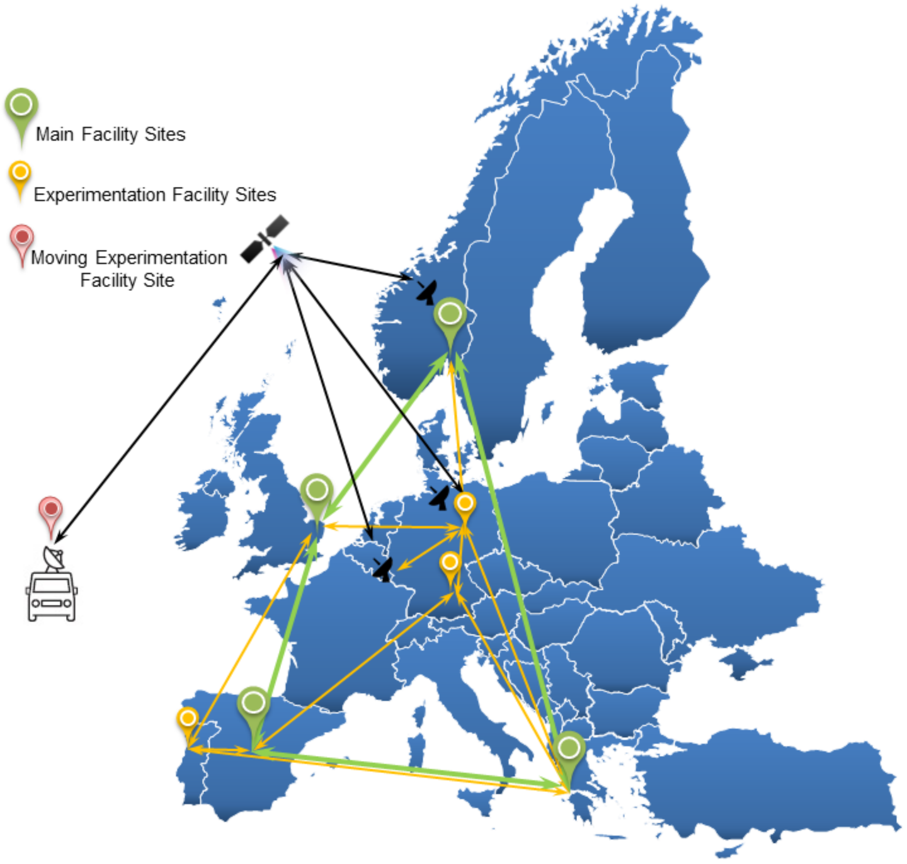
Motivation

- **Experimentation** is a driving force in the evolution of 5G
  - Mobile Network Operators (MNOs), Service Providers, Vendors, etc.
    - ✓ shape of 5G ecosystem / novel business models
  - Vertical stakeholders
    - ✓ acceleration of 5G adoption
- EU-funded **Experimentation Platforms** → 5G-VINNI, 5G-EVE, 5Genesis
  - Offer **Experimentation as a Service (EaaS)** to vertical stakeholders
  - … beyond the lifetime of the projects /explore **commercialization of EaaS** offerings
    - → *Long-term **sustainable business models** are necessary*
- **5G/6G networks** are designed with no predefined services.
  - can be conceived as innovations "platforms"
    - → *MNOs interested in **commercial EaaS business models***

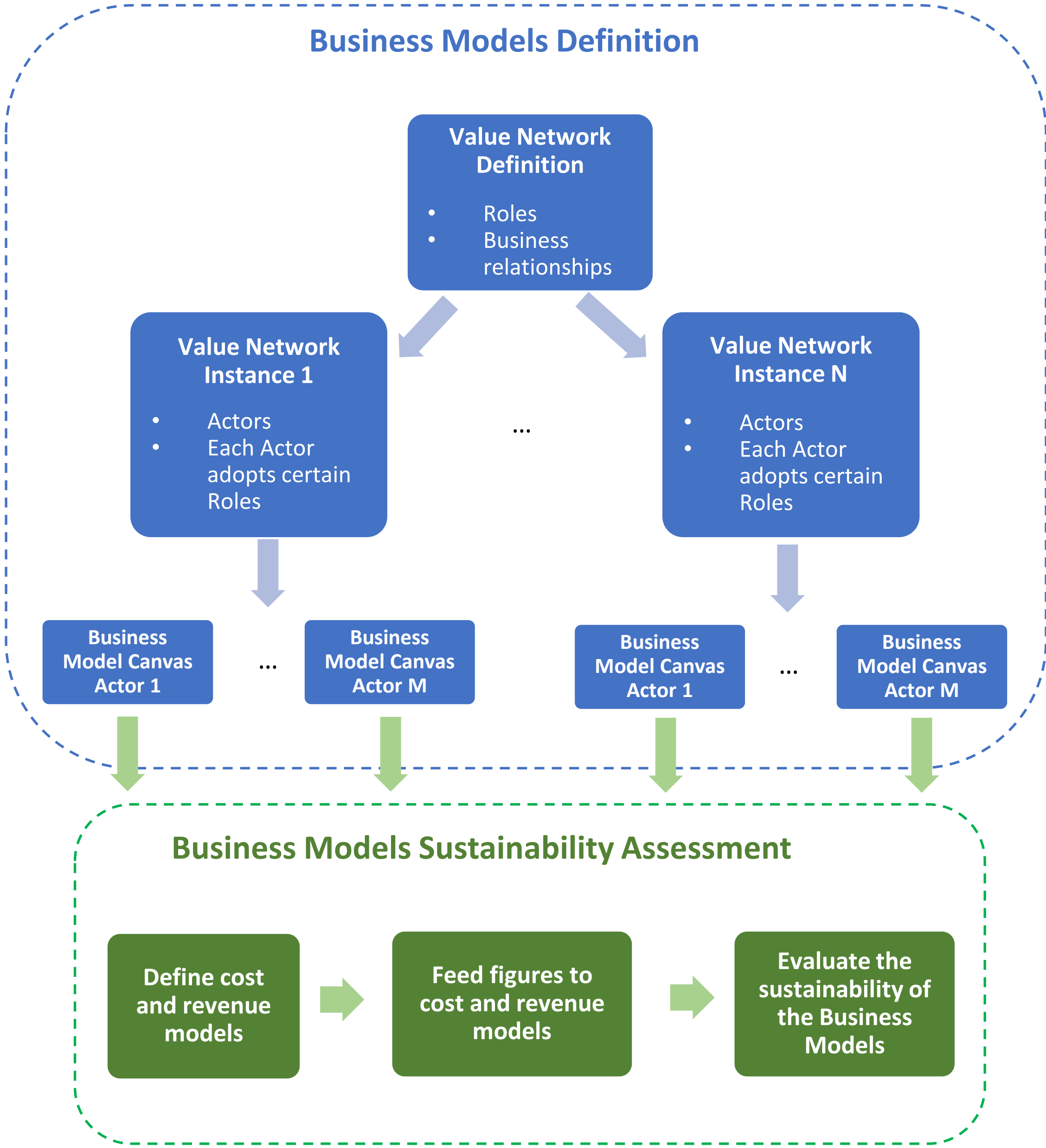


5G-VINNI

Our Contribution

- We introduce **novel business models** for the **main actors** in:
  - Pre-commercial **5G Experimentation platforms**, e.g., 5G-VINNI
  - A potential **5G EaaS market**

- **Methodology**
  - **Value Network of 5G EaaS →** Actor Roles and Business Relationships
  - **Value Network Instance →** Actors adopt certain roles
    - ✓ Aggressive vs Conservative instances
  - **Business Models Canvas →** Key partners, customer segments, value proposition, cost and revenue streams, etc.
  - **Sustainability Assessment →** Assess under different vertical market conditions
    - ✓ Concentrated vs Competitive markets



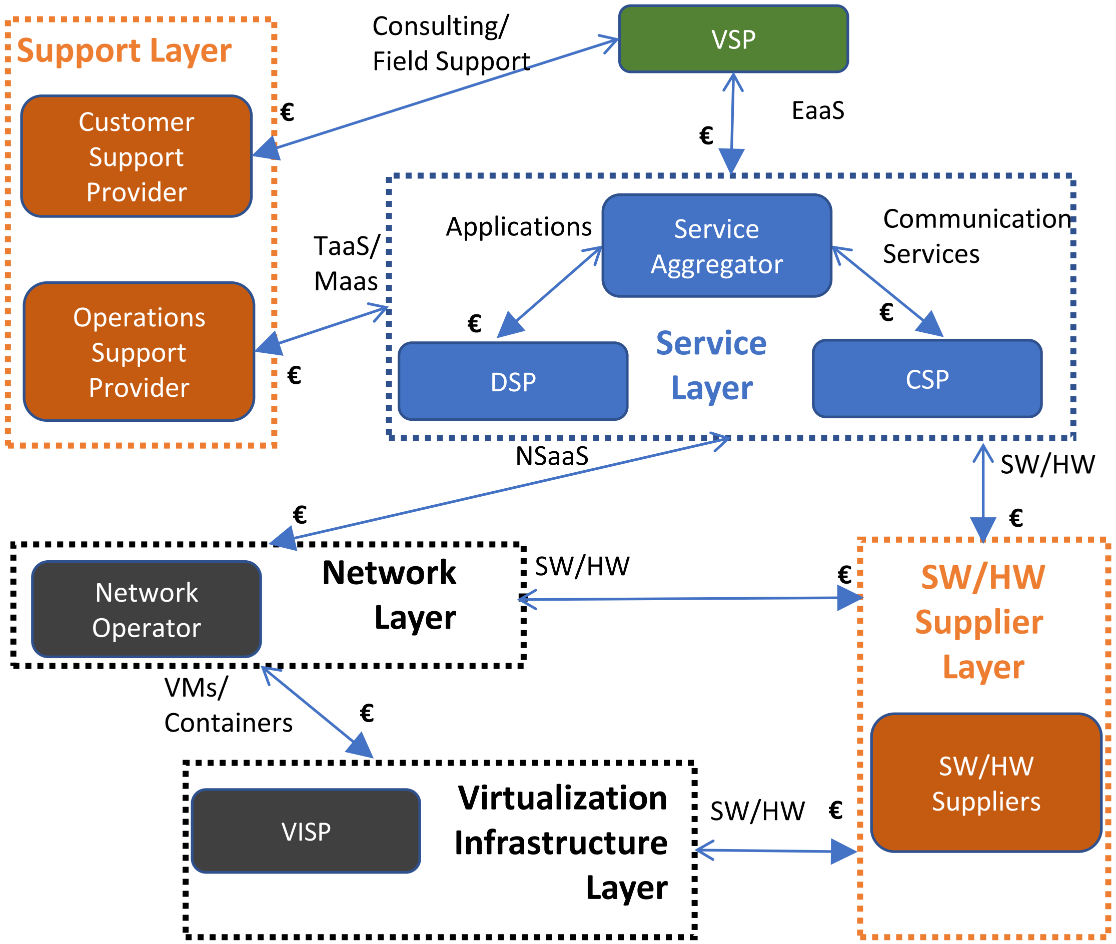
5G Experimentation Value Network

Actor Roles

- **Network and Infrastructure Layers**
  - Network Operator, Virtualization Infrastructure Provider
- **Service Layer**
  - Communication Service Provider (CSP), Digital Service Provider (DSP), Service Aggregator
- **Vertical Service Providers (VSPs)**
- **Support and Supplier Layers**
  - Customer Support Provider, Operations Support Provider, SW/HW Suppliers

Main enabler services for EaaS

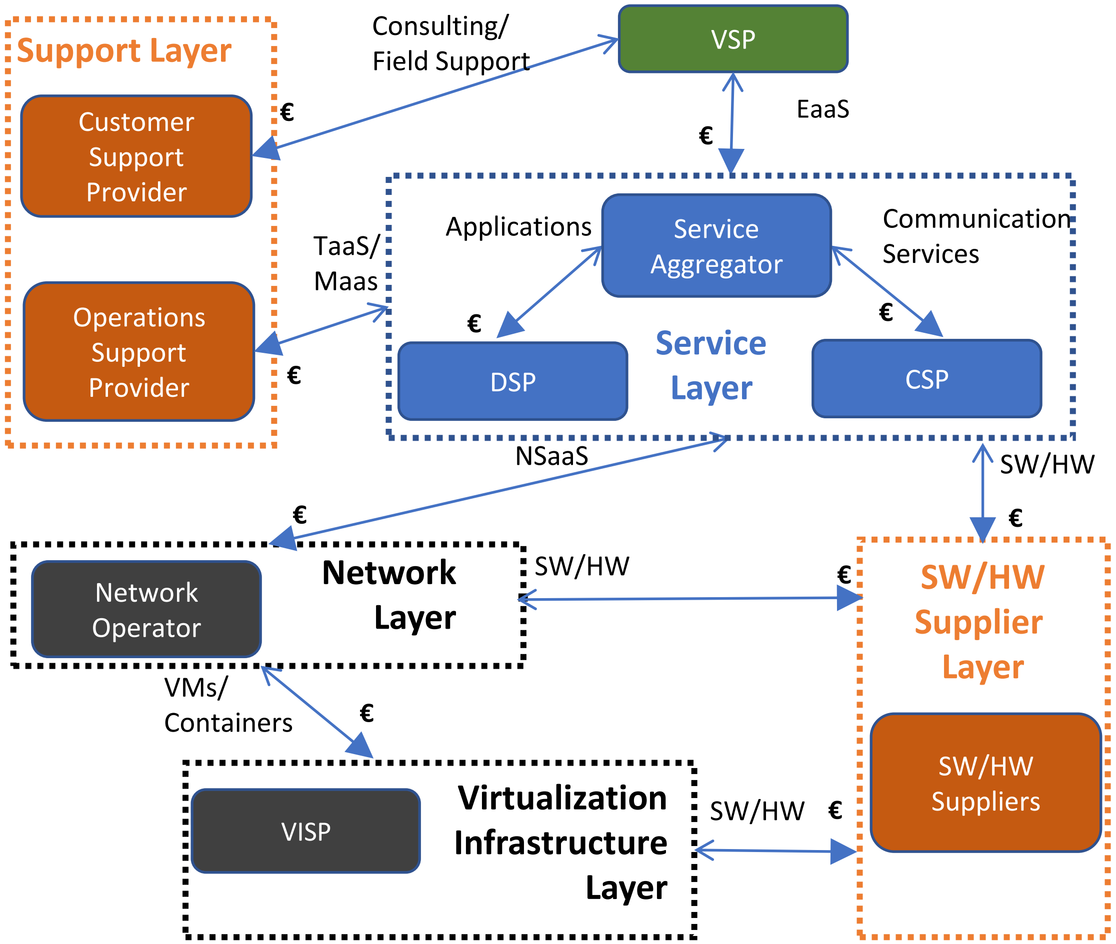
- Network Slice as a Service (NSaaS)
- Testing as a Service (TaaS)/ Monitoring as a Service (MaaS)
- Field Support/Consulting
- Communication Services/ Applications



Main actors

Main Actors

- ***Solution Provider (SP)***
  - one or more roles at the **Service Layer**
  - *may adopt* Customer Support Provider role
- ***Experimentation Infrastructure Operator (EIO)***
  - *always* active at the **Network and Infrastructure layers**
  - *may be* active at the **Service Layer**
  - *may* adopt the role *of* Customer Support Provider
- ***Experimentation Support Provider (ESP)***
  - active at the Support and Supplier Layers

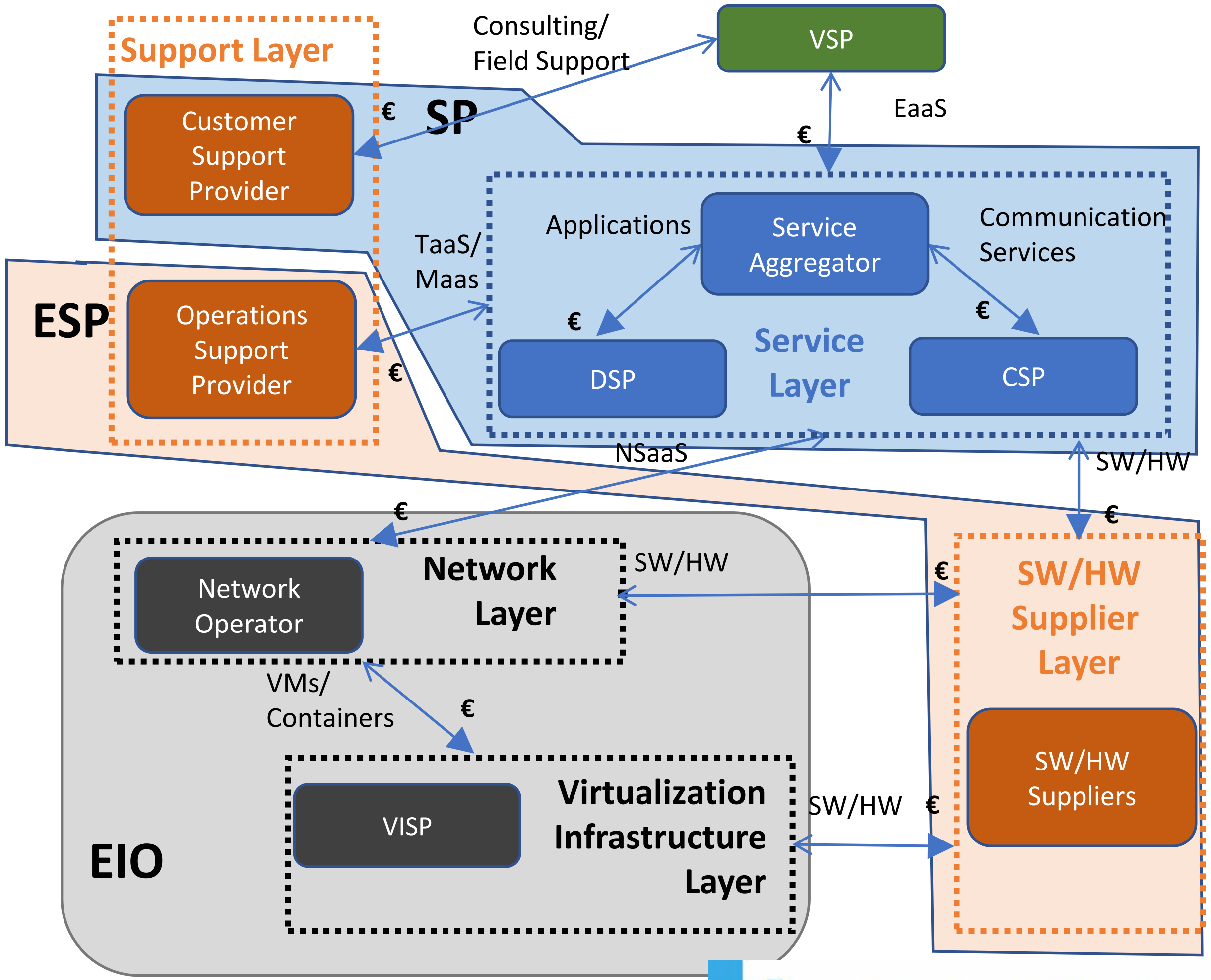


5G-VINNI

Value network Instances (I)

Conservative EIO Instances

- **EIO** adopts only the **Network Operator** and **VISP** roles
  - offers NSaaS to the **SP**
- **SP** adopts **all Service layer** roles
  - offers EaaS to the **VSP**
- **ESP** adopts the **Operation Support Provider** role
  - offers the TaaS/MaaS to the **SP**



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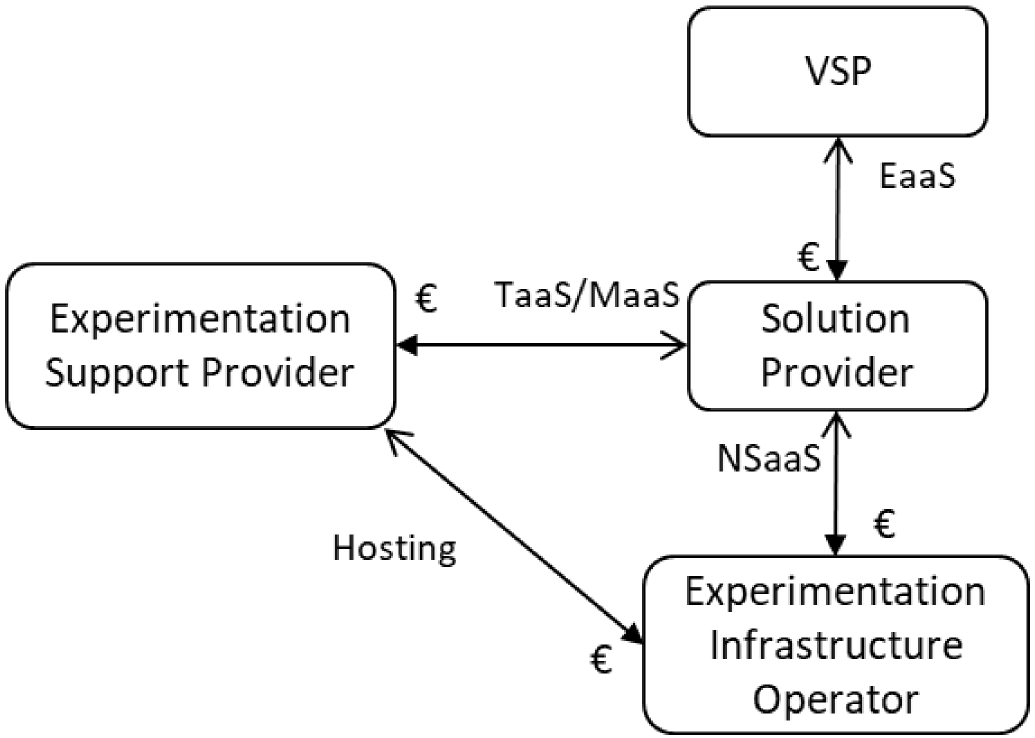
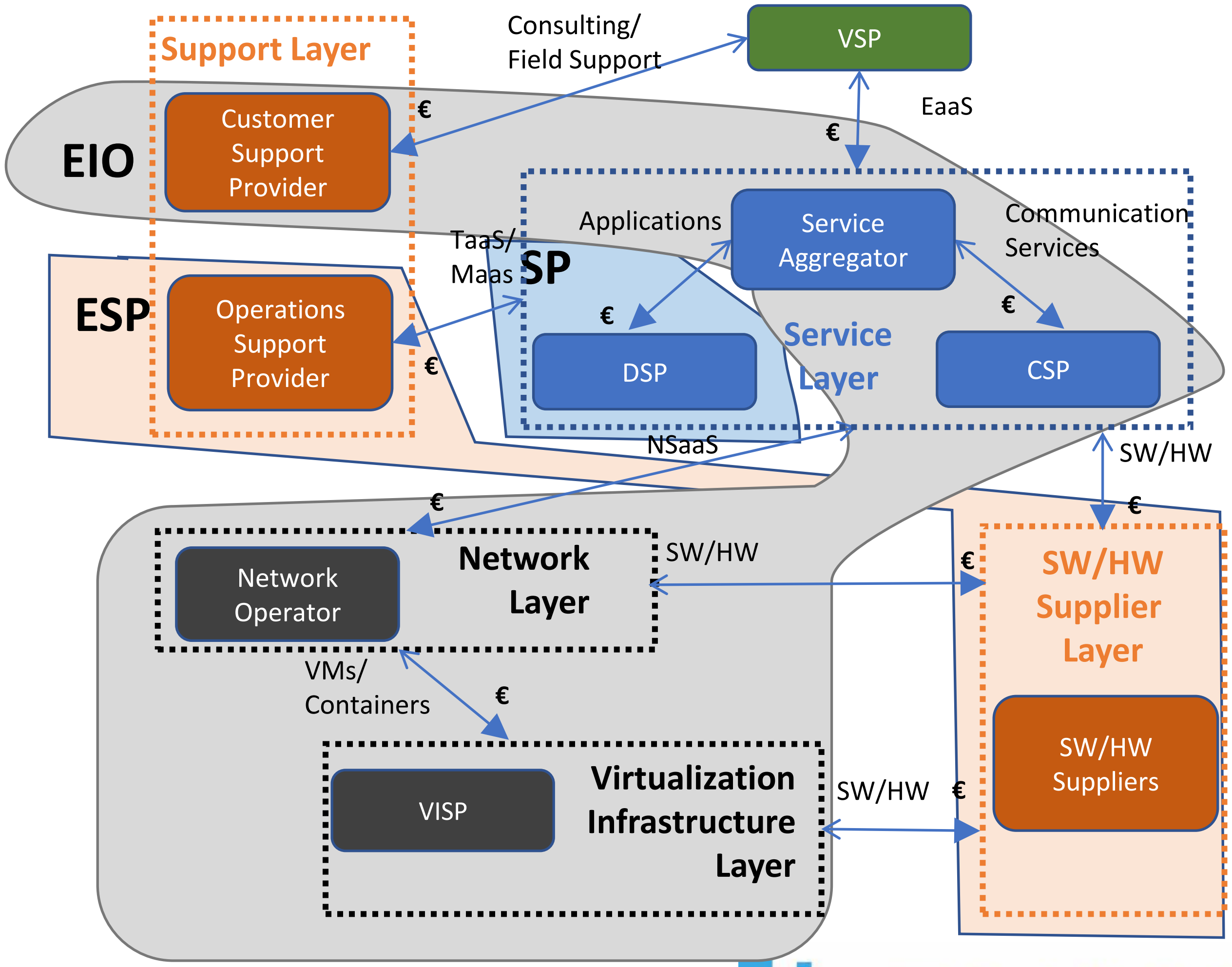


Value network Instances (II)

Aggressive EIO Instances

- **EIO** adopts roles in **Network Operator**, **VISP**, **CSP** and **Service Aggregator** roles
  - offers EaaS to the **VSP**
- **SP** adopts **only** the **DSP role**
  - offers applications to the **EIO**
- **ESP** adopts the **Operation Support Provider** role
  - offers the TaaS/MaaS to the **EIO**



5G-VINNI

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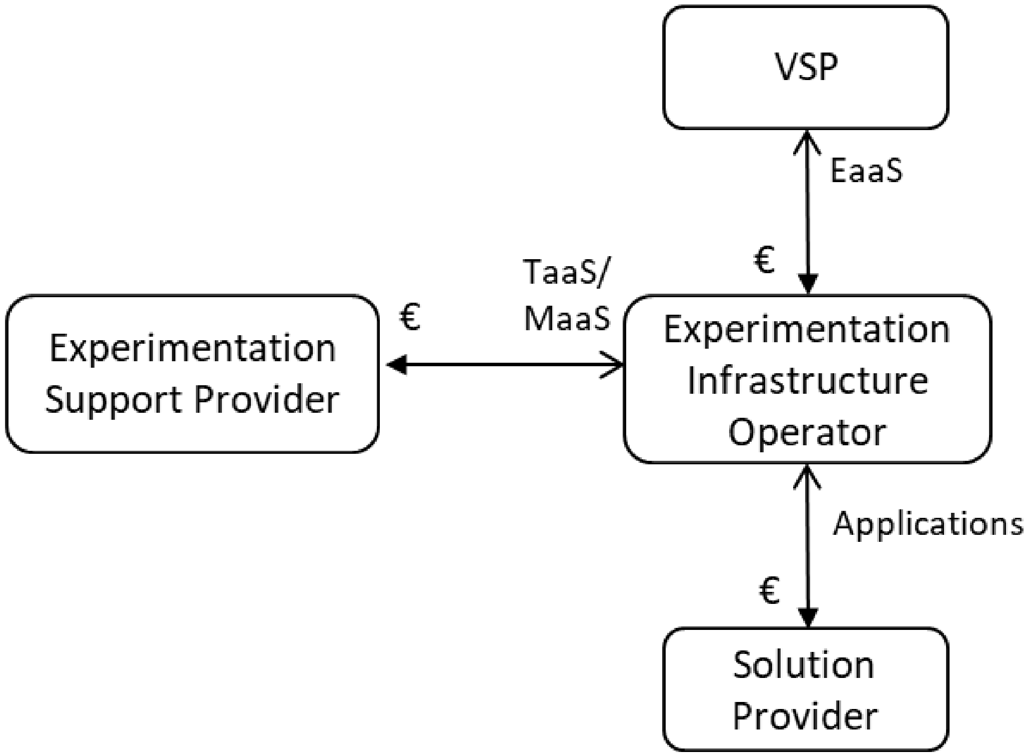


Business Models Canvas

Business Models Canvas of each of the **main actors** (i.e., EIO, SP, ESP), under both **conservative** and **aggressive** value network instances.

- Value Proposition
- Key partners
- Customer segments
- Cost Structure
- Revenues Streams
- Key activities
- Key resources
- Customer Relationships
- Channels

Table 1: BMCs of the SP for the conservative and aggressive instances.

SP	Conservative	Aggressive
Value Proposition	- VSPs can experiment with novel applications/ solutions for certain use cases, in close-to- commer… - Consu… willing… lack the…	Adds value to the EaaS platform by complementing the EIO's service with…
Key Partners	- EIOs… enabling… of verti… - ESPs… MaaS f…	
Customer Segments	VSPs th… the 5G… SP is ac…	
Cost Structure	OPEX: … framew… Experim…	

Table 2: BMCs of the EIO for the conservative and aggressive instances.

EIO	Conservative	Aggressive
Value Proposition	- NSaaS offerings to SPs with guaranteed QoS and value-added functionalities, in a close-to-commercial 5G infrastructure, at a lower cost… house solu… - Hosting t… (i.e., ESPs)… VNFs/VA…	- EaaS offerings to VSPs, who can experiment, at low cost, with novel 5G-enabled applications, to validate whether the requirements of their use cases are satisfied.
Key Partners	SW/HW S… that supply… necessary… component…	
Customer Segments	- SPs that a… at the Serv… i.e., DSPs,… SAs. An S… solutions t…	

Table 3: BMC of the ESP for both conservative and aggressive instances.

ESP	Both for conservative and aggressive
Value Proposition	A complete experimentation support solution to SP which includes: (*i*) a TaaS/MaaS framework and experimenters support during the experiments' setup, scheduling and execution; (*ii*) performance monitoring during experimentation and measurements collection.
Key Partners	- EIO that hosts the TaaS/Maas framework - SW/SW suppliers (external to the value network)
Customer Segments	SPs from any 5G vertical sector.
Cost Structure	OPEX: Personnel, HW, other SW licenses, Data centre rental costs for hosting VNFs/VAFs.
Revenue Streams	Revenue comes from Solution Providers in two dimensions: *(i)* annual license fee for using TaaS/MaaS framework (repetitive fixed); *(ii)* volume-based pricing, i.e., per experiment, per test, per customer support issue, etc., (repetitive variable)
Key Activities	Development of a highly automated TaaS/MaaS framework; Introduction of novel testing and monitoring methods; High quality experimenter…

Comparative Analysis (I)

- **Cost model (CAPEX/OPEX) →** 5G RAN, transport network, cloud infrastructure, SW licenses, connectivity/network slicing cost, budlings/land, electricity, …
- **Revenue model →** *Cost-based pricing* for EaaS and complementary services, i.e., NSaaS, TaaS/MaaS, 5G-enabled applications, hosting, consulting/field support, …
- Two actors may follow the **same business model** design, but can have **different**
    - cost items
    - unit costs
    - number of units
    - pricing scheme
    - market share/demand

We **evaluate** the introduced business models for a **hypothetical platform** by selecting certain values for the above factors

5G-VINNI

Comparative Analysis (II)

Vertical Markets → 8 vertical domains under two different **market conditions**

Competitive Market

Many "small" SPs with low market power

- SPs alone may *not* be able to convince VSPs to experiment with 5G → **low demand** for EaaS
  - **Conservative EIO**
    - ✓ **low demand** levels for 5G EaaS and thus for NSaaS
  - **Aggressive EIO**
    - ✓ EIOs *can* influence VSPs to experiment with 5G
    - ✓ **high demand** for EaaS
    - ✓ SPs can benefit from offering their Applications through EIO's platform (SWaaS model)

Concentrated Market

Few dominant SPs with high market power

- SPs *can* convince VSPs to experiment with 5G → **high demand** for EaaS
  - **EIO conservative**
    - ✓ **high demand** for NSaaS
  - **EIO aggressive**
    - ✓ SPs *unwilling* to offer their Applications through EIO's platform
    - ✓ EIO has **increased cost** for developing Applications

Comparative Analysis (III)

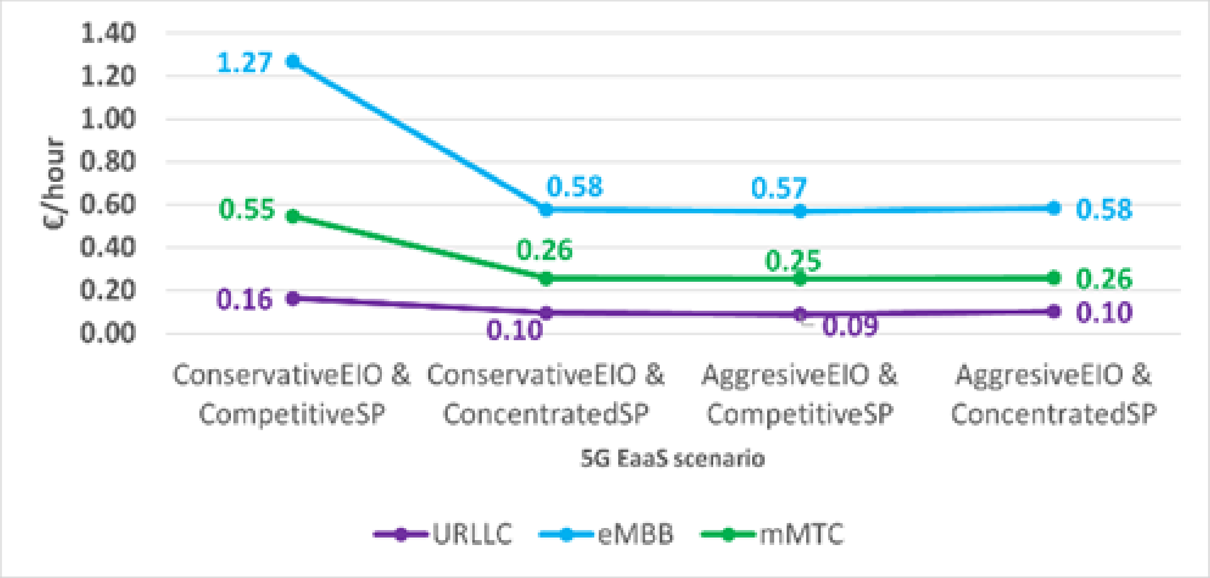
- **Cost-based prices** for all combinations of *value network instance* and *vertical market condition*
  - Service type – eMBB, uRLLC, mMTC
  - Low vs high demand scenarios
  - **Fully Distributed Costs** approach for estimating prices

Table 6: Average number of concurrent 5G sessions per slice type (rounded)

	eMBB	uRLLC	mMTC
"Low demand" scenario	4	6	20
"High demand" scenario	10	10	40

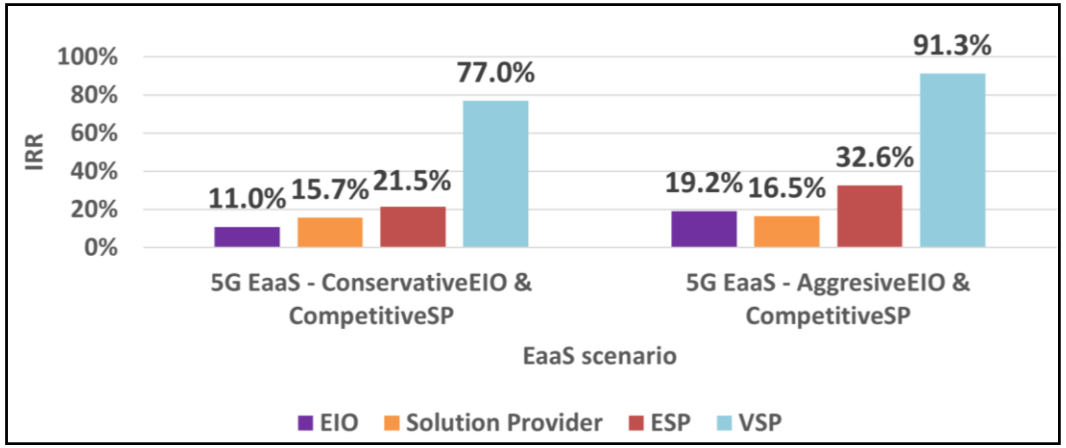
Table 7: Avg. of User and Control Plane load per 5G session per slice type

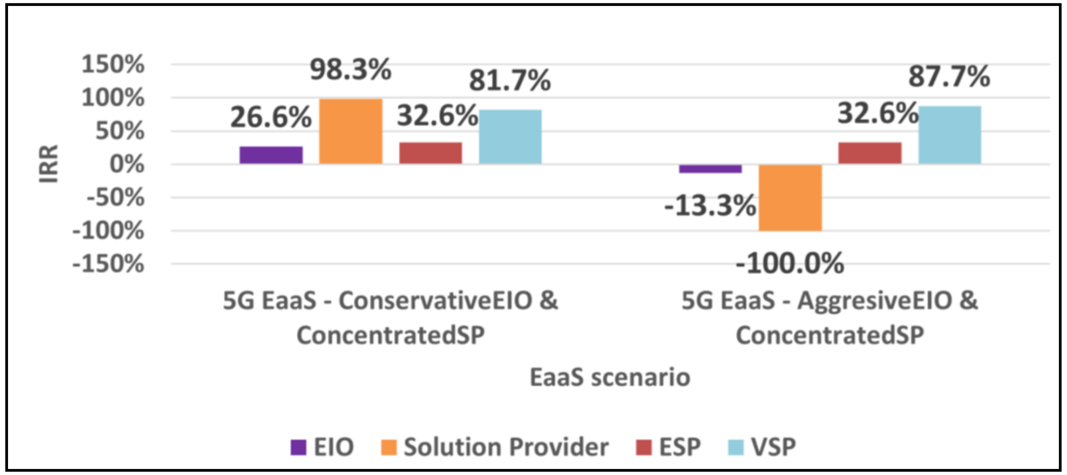
	eMBB	uRLLC	mMTC
User plane	167 Mbps	0.01 Mbps	80 Mbps
Control plane	15 events/sec		



Comparative Analysis (IV)

Profitability (i.e., Internal Rate Return) of business models in a 5-year period





Competitive Market

- **Conservative EIO** → all actors have a positive outlook, with **IRR exceeding 11%.**
- **Aggressive EIO** → EIOs IRR, increases to **19.2%.** *(by attracting more VSPs)*

Concentrate Market

- **Conservative EIO** → all actors have a positive outlook, with **IRR exceeding 26.6%.**
- **Aggressive EIO** → EIOs has negative outlook -**13.3%.**

Conclusions

- We introduced and evaluated **novel business models** for 5G EaaS actors for
  - two instances of 5G Experimentation value network
  - and under different vertical market conditions.

- Our analysis showed that:
  - **Many small Solution Providers** in a vertical market → EIO should choose the **aggressive business model** *(beneficial for all)*
    - ✓ *The conservative business model is also **viable,** but it generates less profit*
  - **Few large Solution Providers** in a vertical market → EIO should choose the **conservative business model** *(beneficial for all)*
    - ✓ *The aggressive business model is **not viable,** unless the SW cost needs to be partly recovered.*

- The directions of future work include
  - The study of additional value network instances
  - Extension of our study for commercial 5G services