Beyond 5G Multi-Tenant Private Networks Integrating Cellular, Wi-Fi, and LiFi, Powered by Artificial Intelligence and Intent Based Policy

5G-CLARITY Deliverable D6.7

Restricted Deliverable on Exploitation Plan

Contractual Date of Delivery:	**November 30, 2021**
Actual Date of Delivery:	**February 28, 2022**
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Work Package:	**WP6**
Target Dissemination Level:	**Confidential**

This document has been produced in the course of 5G-CLARITY Project. The research leading to these results received funding from the European Commission H2020 Programme under grant agreement No. H2020-871428.

Revision History

Revision	Date	Editor /Commentator	Description of Edits
0.1	12/10/2021	Rui Bian (PLF)	TOC; draft main structure; add instructions for partners to provide input
0.2	21/11/2021	Rui Bian (PLF)	First draft with partner's input: BOSCH, IDCC, TID, ACC, PLF, UGR, I2CAT
0.3	24/11/2021	Rui Bian (PLF)	Adding input from partners
0.4	27/11/2021	Rui Bian (PLF)	Integrating VP/Lean canvases
0.5	29/11/2021	Rui Bian (PLF)	Complete List of Acronyms, References; general checks
0.6	29/11/2021	Tezcan Cogalan (IDCC)	Review
0.7	01/12/2021	Rui Bian (PLF)	Full version; all pages in portrait; ready for review
1.0	10/02/2022	Mir Ghoraishi (GIGASYS) Jesús Gutiérrez (IHP)	Final version

Table of Contents

List of Figures

List of Tables

List of Acronyms

3GPP	3rd Generation Partnership Project
5GC	5G Core
5GNR	5G New Radio
AGV	Automatic Guided Vehicle
AI	Artificial Intelligence
AoA	Angle-of-Arrival
API	Application Programming Interface
AT3S	Access Traffic Steering, Switching and Splitting
B2B	Business-to-Business
B5G	Beyond 5G
CAGR	Compound Annual Growth Rate
CIRS	Channel Impulse Responses
CPE	Customer-premises Equipment
CU	Central Unit
DRL	Deep Reinforcement Learning
DU	Distributed Unit
E2E	End-to-End
eAT3S	Enhanced AT3S
ESN	Echo State Networks
GBR	Guaranteed Bit Rate
GNSS	Global Navigation Satellite Systems
HoL	Head-of-Line
IIOT	Industrial Internet of Things
IP	Internet Protocol
IRS	Intelligent Reconfigurable Surfaces
IS	Image Sensor
ISM	Industrial Scientific and Medical
KPI	Key Performance Indicator
LED	Light Emitting Diode
LGV	Laser Guided Vehicles
LiDAR	Light Detection and Ranging
LiFi	Light Fidelity
IMU	Inertial measurement unit
LoS	Line-of-Sight
LSTM	Long Short-term Memory
LTE	Long Term Evolution
MES	Manufacturing Execution System
ML	Machine Learning
mmWave	Millimetre Wave
MNOS	Mobile Network Operators
MPTCP	Multi-Path TCP

NLoS	**Non-Line-of-Sight**
NPN	**Non-Public Network**
NR	**New Radio**
OCC	**Optical Camera Communication**
O-RAN	**Open RAN**
PHY	**Physical layer**
PoC	**Proof-of-concept**
RAN	**Radio Access Network**
RF	**Radio Frequency**
RL	**Reinforcement Learning**
OCC	**Optical Camera Communications**
PC	**Personal Computer**
PNI-NPN	**Public Network Integrated NPN**
PoC	**Proof-of-Concept**
RAN	**Radio Access Network**
RBEF	**Robert Bosch España Fábrica**
RIC	**Radio Interface Controller**
RRM	**Radio Resource Management**
RSS	**Received Signal Strength**
RU	**Radio Unit**
SDK	**Software Development Kit**
SDR	**Software Defined Radio**
SLA	**Service Level Assurance**
SSID	**Service Set Identifier**
TCP	**Transmission Control Protocol**
TDoA	**Time-Difference-of-Arrival**
ToF	**Time-of-Flight**
TRL	**Technological Readiness Level**
TSN	**Time-Sensitive Networking**
UC	**Use Case**
UE	**User Equipment**
UL	**Uplink**
UP	**User Plane**
UWB	**Ultra-wide Band**
VLC	**Visible Light Communication**
VRAN	**Virtual RAN**
WAT	**Wireless Access Technology**
WP	**Work Package**

Executive Summary

This document corresponds to the additional restricted deliverable D6.7, addressing comments received during the project review (July 2021) and reporting on the updated exploitation plan. Particularly, it summarises the exploitable outcomes from the project with classifications into different categories. The methodologies for analysing these exploitable outcomes are described. In addition, the updated individual exploitation plans are presented. This deliverable is positioned as an interim report where the final report on exploitation plan will be presented in 'D6.5 – Final report on innovation management, exploitation and IPR'.

1 Introduction

1.1 Scope and objectives

This document is a restricted deliverable D6.7 on the updated exploitation plan. It corresponds to the 5G-CLARITY T6.4 'Exploitation, Innovation Management and IPR'. The main objective of the 5G-CLARITY WP6 is to create both the broadest awareness of the 5G-CLARITY proposed enabling technologies and their highest impact on the ecosystem.

This deliverable is prepared for addressing reviewers' comments received during the project review meeting happened in July 2021. This deliverable presents the main exploitable outcomes of 5G-CLARITY project while introducing the principles and methodologies followed to identify them. Also, an update on each partner's exploitation plan is reported based on the initial proposal in 5G-CLARITY D6.1 [1]. This deliverable is positioned as an interim update on the exploitation analysis and plan. The final report on such topics will be addressed in '5G-CLARITY D6.5 – Final report on innovation management, exploitation and IPR'.

1.2 Document Structure

This document comprises 5 sections. Following the Excusive Summary and Introduction section:

- Section 2 introduces the principles and methodologies followed in 5G-CLARITY project to identify the exploitable outcomes.
- Section 3 summarizes the main exploitable outcomes identified in 5G-CLARITY and their classification into different pre-defined categories.
- Section 4 presents the exploitation strategy methodology applied by each partner and updates on the individual exploitation plan.
- Section 5 shows the Lean Canvas analysis of each individual use case.
- Section 6 concludes the document.

2 Project Exploitation Outcomes Classification and Methodology

2.1 Exploitation Outcomes Classification

Considering within the 5G-CLARITY project partners are ranging from academic to industrial sectors, the diversity of expertise and prospects are reflected to their exploitation strategy and activities. In particular, the University and Research Centres partners usually focus on exploitation activities of research items, while large companies and SMEs are mainly interested in commercial exploitation of products.

In the 5G-CLARITY project, the outcomes have mainly been classified in the following three categories:

- **Prototype/Products:** the outcome delivered for developing or enhancing specific products by:
  - delivery of Prototypes - Stand-alone products,
  - implementing/improving new functions or services.
- **Research Achievement:** the outcome adds to the body of knowledge and will be delivered to academic or industry through dissemination paths.
- **Demonstrators:** the outcome that would be implemented as Demonstrators in the field or in lab environment. In 5G-CLARITY, this category mainly includes the several Use Case (UC) demonstrators.

2.2 Exploitation Strategy Methodology

To analyse the exploitable potentials of each given product or result in the 5G-CLARITY project, two prevailing models for customer centric identification are being considered: 1) the Value Proposition (VP) Canvas and 2) the Lean Canvas. Both methodologies are presented in the following sections. For each exploitable outcome of the 5G-CLARITY project, the following steps are followed to perform the structed analysis:

- The first step for each exploitable outcome is to be associated with the Exploitation Type among the three categories described in the previous section. The Owner of each outcome is also identified. The collected information is assessed and summarised in the final table of exploitation outcomes.
- For the items under **Prototypes/Products** category, the Value Proposition Canvas is filled. Through the identification of gains, pains and opportunities, a clear and structed value proposition statement for the outcome is provided. Then for some outcomes with more promising value propositions, the Lean Canvas methodology is applied to further analyse the exploitation potential and identify the key aspects to build the related business case. In addition, the individual exploitation plan from each partner has been described and updated associated with the exploitable outcomes of their responsibility.
- For the items under **Research Achievement** category, they have been analysed in terms of their value in the individual partners' exploitation plans.
- For the items under **Demonstrator** category, the Lean Canvas is applied to analyse the potential exploitation values.

2.2.1 Value Proposition Canvas Methodology

The Value Proposition Canvas [2] as shown in Figure 2-1 is a business model tool that helps to make sure a product or service is positioned around customers' values and needs. The primary purpose is to create a fit

between the product and market. For this to happen, the Value Proposition Canvas explores deeply in the two blocks: Customer Profile and Value Map.

The Customer Profile described target customer profile with key information to understand the expectation from customers regarding the results generated in 5G-CLARITY. More specifically it contains:

- **Customer Jobs**: this is about what the customer is trying to do, including the tasks customers are trying to perform, the problems they are trying to solve, and the needs they want to satisfy.
- **Pains**: this encompasses everything that annoys the customer while they are performing the jobs, without applying 5G-CLARITY solutions, such as negative experiences, challenges, risks, mistakes, etc.
- **Gains**: this is all the benefits and outcomes the customer expects to achieve.

The Value Map is used to identify information regarding the features of a product or service targeting the specific customers. More specifically it contains:

- **Products & Services**: the product or service delivered in 5G-CLARITY to the specific Customer Profile.
- **Pain relivers**: the ways how the 5G-CLARITY product/service will relieve the Customer Pains.
- **Gain creators**: this involves how the product/service offers the customer added value, and what are the benefits they bring.

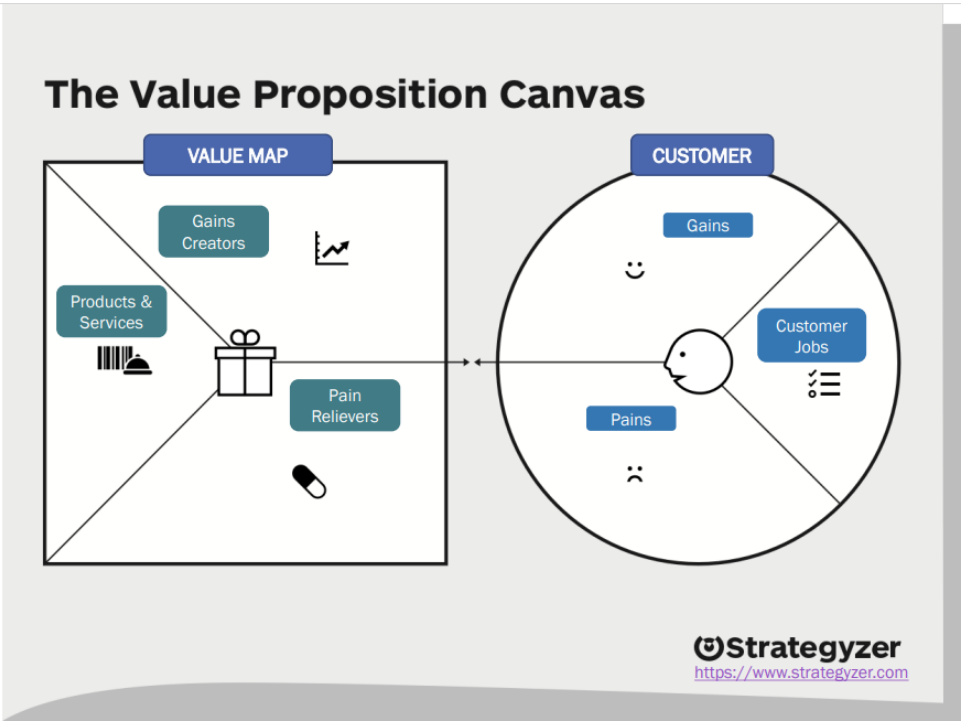


Figure 2-1: Value Proposition Canvas model

2.2.2 Lean Canvas Methodology

The Lean Canvas, as shows in Figure 2-2, is a business modelling tool to help deconstruct a start-up idea into its key and most risky assumptions. The methodology is adapted from the Business Model Canvas [3][4], with the modifications on the nine blocks in a logical order that begins from the customer's problem. More specifically it contains:

- **Problem**: the top problems the 5G-CLARITY solution will solve.

  - **Existing Alternatives**: lists how these problems are solved today.

- **Solution**: a brief description of what the 5G-CLARITY solution does and how it is different from the alternatives.
- **Key Metrics**: Key activities that will be measured to track the success.
- **Unique Value Proposition**: Single, clear, compelling message that states why the 5G-CLARITY solution is different and work paying attention.
- **Unfair Advantage**: something that cannot easily be bought or copied.
- **Channels**: Channels to be used to contact customers, promote and deliver the value promised.
- **Customer Segment**: The targeted customer profile.
  - **Early Adopters**: lists the characteristics of the ideal customer.
- **Cost Structure**: lists the fixed and variables costs for applying the solution.
- **Revenue Streams**: the main revenue streams generated from the commercialisation/provision of the solution to the market.

Figure 2-2: Lean Canvas model

3 Identification and Classification of 5G-CLARITY Exploitation Outcomes

3.1 Summary of exploitable outcomes and owner

The exploitable outcomes of the 5G-CLARITY project include pure research results, individual products and integrated demonstrators for specific use cases. The exploitable outcomes list and classification is summarised in Table 3-1 with the corresponding owner. In addition, the methodology that has been applied to analyse the exploitation potential of each outcome has been clarified in the table.

Table 3-1: Identification, Classification and Methodology of 5G-CLARITY Exploitable Outcomes

#	Exploitation Outcome	Type	Methodology	Owner
1	**UC1: Enabling Enhanced Human-Robot Interaction (Smart Tourism)**	Demonstrators	Lean Canvas	UNIVBRIS, UGR, I2CAT, ACC, PLF, USTRATH
2	**UC2.1: Alternative Network to Exchange Production Data (Industry 4.0)**	Demonstrators	Lean Canvas	TID, BOSCH, I2CAT, ACC, IDCC, ACC, PLF
3	**UC2.2: Enhanced AGV Positioning for Intralogistics (Industry 4.0)**	Demonstrators	Lean Canvas	IHP, BOSCH, I2CAT, USTRATH, PLF
4	**Multi wireless access technology (4G/5G/WiFi/LiFi) open RAN with AI/ML xApps**	Prototypes/Products	VP/Lean Canvas	ACC
5	**RAN Controller Improvement (new Features)**	Prototypes/Products	VP/Lean Canvas	I2CAT
6	**Slice Manager improvements (new Features)**	Prototypes/Products	VP/Lean Canvas	I2CAT
7	**Industrial CPE Wifi6 + 5G (+LiFi)**	Prototypes/Products	VP/Lean Canvas	I2CAT
8	**OCC positioning system**	Prototypes/Products	I2CAT Exploitation Plan	I2CAT
9	**Adaptive AI-based defect-detection in a smart factory**	Prototypes/Products	VP/Lean Canvas	IDCC
10	**Robotic and AI Assisted B5G Services across Multi-domain Private and Public Networks**	Prototypes/Products	VP/Lean Canvas	UNIVBRIS
11	**Guide Robot for public safety**	Prototypes/Products	VP/Lean Canvas	UNIVBRIS
12	**Localization server supporting multiple wireless localization technologies**	Prototypes/Products	VP/Lean Canvas	IHP
#	**Exploitation Outcome**	**Type**	**Methodology**	**Owner**
13	**Downlink time difference of arrival sub-6 GHz and two-way-ranging (TWR) based mmWave localization system**	Prototypes/Products	VP/Lean Canvas	IHP

14	**APIs enabling network capability exposure in PNI-NPN scenarios**	Prototypes/Products	TID Exploitation Plan	TID
15	**LiFi integration for the multi-RAT management platform**	Prototypes/Products	VP/Lean Canvas	PLF
16	**LiFi positioning system**	Prototypes/Products	VP/Lean Canvas	PLF
17	**Kernels 5.4 and 5.5 binaries and sources with MPTCP with a Weighted Round Robin scheduler and API**	Research Achievement	UGR Exploitation Plan	UGR
18	**dRAX plugin to gather MPTCP telemetry**	Research Achievement	UGR Exploitation Plan	UGR
19	**Virtualized multi-connectivity framework**	Research Achievement	UGR Exploitation Plan	UGR
20	**5G-CLARITY multi-WAT scheduler**	Research Achievement	UGR Exploitation Plan	UGR
21	**Deep Reinforcement Learning (DRL)-assisted solution for resource partitioning in a multi-technology Radio Access Network (RAN)**	Research Achievement	UGR Exploitation Plan	UGR
22	**Deep Reinforcement Learning (DRL)-assisted solution for dynamic transport network setup and computing resources provisioning**	Research Achievement	UGR Exploitation Plan	UGR
23	**Potential Game-based method for computing wireless quota of GBR services in RAN slicing**	Research Achievement	UGR Exploitation Plan	UGR
24	**MPTCP testbed REST-API**	Research Achievement	USTRATH Exploitation Plan	USTRATH
25	**OWCsimPy**	Research Achievement	USTRATH Exploitation Plan	USTRATH
26	**Intelligent eAT3S Oracle**	Research Achievement	USTRATH Exploitation Plan	USTRATH
27	**Multi-Policy Scheduler (MPS)**	Research Achievement	USTRATH Exploitation Plan	USTRATH
#	**Exploitation Outcome**	**Type**	**Methodology**	**Owner**
28	**AI/ML supported flexible intent interpretation**	Research Achievement	LMI Exploitation Plan	LMI

3.2 5G-CLARITY Exploitable Outcomes of Type "Prototype/Product"

Table 3-2 describes exploitable outcomes of the type "Prototype/Product" within the 5G-CLARITY project.

Table 3-2: Exploitation Outcomes of Type "Prototypes/Products"

Prototypes/Products	Owner
Multi wireless access technology (4G/5G/WiFi/LiFi) open RAN with AI/ML xApps	**ACC**
Accelleran will exploit the enhancements made in the project from their current neutral-host enabled cloud-native 4G dRAX commercial offering towards an Open and Disaggregated RAN neutral-host enabled cloud-native multi wireless access technology (4G/5G/WiFi/LiFi) dRAX RIC platform enabling support for intelligent AI/ML xApps.	
RAN Controller Improvement (new Features)	**I2CAT**
I2CAT will exploit the improvements and additional features included in its current asset RAN controller, declared as background for the project. The RAN controller is an innovative solution to manage the radio and transport resources, it has been enhanced to enlarge its portfolio of supported technologies adding: Lifi, Wifi6 and Accelleran 5GNR.	
Slice Manager improvements (new Features)	**I2CAT**
I2CAT will exploit the improvements and additional features included in its current asset Slice Manager. The solution can define slices across different technologies, and it is vendor agnostic. I2CAT has bundled this technology with RAN controller and exploits them through its spin off Neutroon.	
Industrial CPE Wifi6 + 5G (+LiFi)	**I2CAT**
I2CAT will exploit the Industrial Customer Premises Equipment (CPE) Wifi6 + 5G (+LiFi) as a key element to enlarge the device pool that can be connected to the raising market of the private networks. The integration of multi access technologies on a single CPE adds flexibility on the connectivity plane and enables the network management team to use versatile configurations. We plan to exploit it together with the manufacturers of industrial equipment by integrating the solution on their Operative System and also to use channels like Neutroon to deliver the infrastructure application required.	
OCC positioning system	**I2CAT**
I2CAT will exploit its Optical Camera Communications Positioning System, an indoor positioning solution based on visible light communications (VLC) which has been enhanced during the course of the project. Our main target is the AGV manufacturers ecosystem, especially those who have large fleets, so the infrastructure cost is less relevant.	
Adaptive AI-based defect-detection in a smart factory	**IDCC**
InterDigital plans to integrate some of the 5G-CLARITY solutions into its portable production line Proof-of-Concepts (PoC) platform which will be used to demonstrate 5G-CLARITY solutions at relevant exhibitions and conferences, including the Mobile World Congress (MWC) and the European Conference on Networks and Communications (EuCNC). More specifically, a production line and robotic application that will identify defective items on the production line via AI-based defect detection application will be enhanced by assessing new hybrid slicing/multi-connectivity solutions allowing to simultaneously meet high-bandwidth demand and low-latency requirement dictated by such applications.	
Robotic and AI-Assisted B5G Services across Multi-Domain-Private and Public Networks	**UNIVBRIS**

The Smart Internet Lab of the University of Bristol (UNIVBRIS) plans to integrate the 5G-CLARITY solutions with the guide robot to create a proof of concept of *Robotic and AI-Assisted B5G Services across Multi-Domain-Private and Public Networks* by allowing robotic assistant or guide robots connected to an AI framework enabling beyond 5G (B5G) *multi*-wireless technologies (multi-WAT) to provide on demand services through E2E slicing across multi-domain, public and private networks (e.g., NFIaaS, SLaaS, and WATaaS) in malls, airports, train stations, hospitals, museum, universities, and many other public and private venues.
Guide Robot for public safety — **UNIVBRIS**
The Smart Internet Lab of the University of Bristol (UNIVBRIS) plans to use the integration of the 5G-CLARITY solutions with the guide robot to build and validate a prototype of a "*Guide Robot for public safety".* The prototype to be deployed and validated during the project will perform face recognition and threat and emergency detection while assisting visitors and staff. The prototype will be equipped with a 360-degree camera and AI assisted object detection and on demand emergency connectivity for Security forces (e.g., police officers) and Emergency Services (e.g., paramedics) to be provided locally and/or remotely. The solution also will exploit the high bandwidth, low latency, and flexibility of Multi-WAT B5G technology with the robot capability to monitor the surroundings and interact and support humans.
Localization server supporting multiple wireless localization technologies — **IHP**
IHP will develop and integrate a localization server to make use of the positioning capabilities for the different 5G-CLARITY WATs. Within this project, the main focus would be on the concepts for the localization server as well as the functionalities being implemented into it. The main goal would be to describe how positioning data would be exchanged between the localization server, the WATs and the users requiring positioning data. Additionally, IHP proposed a data fusion approach that was implemented and tested in simulation.
Downlink time difference of arrival sub-6 GHz and TWR based mmWave localization system — **IHP**
Within this project, IHP is mainly involved in the development and enhancement of a combined Sub-6 GHz and mmWave positioning solution. The details of these systems and the initial evaluation of their performance are given in deliverable D3.2 [6]. The developed positioning solutions are intended for indoor deployment and indoor positioning of a User Equipment (UE) using RF signals. Both solutions are intended to be deployed in the ISM bands at 2.4/5 and 60 GHz. Additionally, these solutions should serve as a proof of concept for indoor localization, which later can be integrated in the future WLAN positioning standards or used in proprietary positioning systems.
APIs enabling network capability exposure in PNI-NPN scenarios — **TID**
Some customers, specially advanced vertical customers and hypercalers, are willing to consume network capabilities in the context of PNI-NPNs. The on-demand, secure and controlled (auditable) exposure of these network capabilities to 3rd parties may be one of the main ways to monetize investment in fibre, edge computing and 5G. To ensure wide market adoption and an attractive economy of scale for operators and their customers, it essential to push the industrialization of open, global and interoperable APIs for network capability exposure. In this regard, Telefónica in cooperation with other industry partners (operators, vendors, hyperscalers, developers and system integrators) has constituted an open-source initiative to foster the definition, development, testing and validation of APIs, in PNI-NPN scenarios. Telefónica leverages outcomes from 5G-CLARITY to propose API specifications and validate them in their lab facilities with 5G assets (through test campaigns), before getting these APIs certified and moved to production networks. These contributions are led by the TID team.
LiFi integration for the multi-RAT management platform — **PLF**
This development for LiFi integration to the multi-RAT management platform is based on the existing LiFi-XC product. LiFi related components (such as Netconf interface support to configure AP, Prometheus exporter support for telemetry) are developed by PLF in order to work with the multi-RAT platform developed in 5G-CLARITY. PLF will exploit this work as an additional function/service to the existing LiFi products.

LiFi positioning system	PLF
This work is not a stand-alone LiFi location system, but it is built on top of the LiFi-XC system. It uses the multiple received signal strength values from different APs to estimate the user location, while the main data communication function is maintained. PLF will exploit the experience and result acquired in the LiFi positioning system development as an additional function to the existing LiFi-XC product.	

3.3 5G-CLARITY exploitable outcomes of type "Research Achievement"

Table 3-3 describes the exploitable outcomes of the type "Research Achievement" within the 5G-CLARITY project.

Table 3-3: Exploitation Outcomes of Type "Research Achievement"

Research Achievement	Owner
Kernels 5.4 and 5.5 binaries and sources with MPTCP with a Weighted Round Robin scheduler and API	**UGR**
These kernels were tested so the wireless interfaces for WIFI 6 provided a high performance. These implementations, and the documentation provided along the binaries, may facilitate the adoption of MPTCP in modern Linux boxes, leveraging the use and development of applications which may take advantage of the sharing of multiple network interfaces. Additionally, the binaries with the 5G-CLARITY scheduler implementation for MPTCP, a Weighted Round Robin (WRR) scheduler, has been provided along with the previous kernels. This scheduler allows the designing and deployment of more controlled transport layer services to take the most of each available interface. This implementation should provide better performance than the Round Robin scheduler for interfaces with different characteristics. To allow the design of intelligent transport layer's services, we have developed an API which facilitates the remote control of the MPTCP schedulers' parameters. This API will permit machine learning (ML) frameworks to extract state information from the MPTCP socket, as well to launch MPTCP related actions from ML models. This will ease the application of ML to this kind of network operations.	
dRAX plugin to gather MPTCP telemetry	**UGR**
The API developed to access to the state information of the MPTCP schedulers allows to implement a probing module which can be called by a dRAX server. To that end, a dRAX plugin for gathering the telemetry of an open MPTCP socket will be implemented. This plugin will allow administrators and developers to use remote information of MPTCP based services to (re)configure and take RAN related actions to improve the performance of the wireless networks.	
Virtualized multi-connectivity framework	**UGR**
The virtual testbed developed for the 5G-CLARITY's multi-connectivity framework will allow other implementors and researchers on 5G with multi-connectivity support to boost their designs.	
5G-CLARITY multi-WAT scheduler	**UGR**
This scheduler allows the designing and deployment of more controlled transport layer services to take the most of each available interface. This implementation should provide better performance than the Round Robin scheduler for interfaces with different characteristics. Its API may allow the rapid development of ML based models for controlling and adjusting traffic between different wireless links.	
Deep Reinforcement Learning (DRL)-assisted solution for resource partitioning in a multi-technology Radio Access Network (RAN) and Deep Reinforcement Learning (DRL)-assisted solution for dynamic transport network setup and computing resources provisioning	**UGR**
These algorithms leverage analytical performance models to speed up the RL agents training process, the feasibility	

check of the actions issued by the agent, i.e., to filter those actions that do not meet any optimization constraint (e.g., 5G streams performance requirements), and estimate performance measurements that are not available (e.g., worst-case end-to-end delay and jitter). To date, RL-based algorithms for the resource allocation in multi-Wireless Access Technology RANs and the configuration of asynchronous Time-Sensitive Networking (TSN) networks are under development. 5G-CLARITY5G-CLARITY

The UGR´s exploitation plan regarding these ML-based algorithms comprises the generation of high impact scientific publications describing the key findings, results, and contributions.

Potential Game-based method for computing wireless quota of GBR services in RAN slicing	**UGR**

The 5G-CLARITY project has proposed a technological solution to deploy and operate E2E network slices over private and/or public network. Focusing on the RAN, the 5G-CLARITY project has proposed the definition of resource quotas per RAN slice. These quotas allow to guarantee the performance requirements of those network slices which are deployed in a private venue throughout their lifetimes; and limit the maximum radio resources allocated to them.

5G-CLARITYTo shed light on the establishment of these resource quotas, the UGR team has proposed a game theory-based solution to compute the radio resource quotas for multiple RAN slices which accommodates specific communication services with requirements in terms of Guaranteed Bit Rate (GBR). Specifically, the UGR's solution allows to plan the deployment of multiple RAN slices to (a) meet their GBR requirements throughout their lifetime, and (b) guarantee the probability of blocking user sessions in these RAN slices is below a certain threshold.

The UGR´s exploitation plan regarding the computation of resource quotas comprises the generation of high impact scientific publications with the most relevant contributions and results.

MPTCP testbed REST-API	**USTRATH**

This innovation offers a REST-API design and evaluation for testbeds which have MPTCP installed. Specifically, a high-level API that conforms to the REST specification and sits between application and kernel layers is designed, as the existing APIs for MPTCP kernels were very low level and not standardized. This innovation could be used to enable easy access for a reinforcement learning (RL) agent and manage MPTCP-enabled testbeds. Also, by enabling easy access for software developments to create an interactive dashboard to monitor and configure MPTCP-enabled testbeds.

OWCsimPy	**USTRATH**

This innovation offers a lightweight open-source library that can generate channel impulse responses (CIRs) for LiFi channels within a specific 3D environment. Similar libraries and/or software solutions both in the literature and commercial applications are either closed source or difficult to scale. Thus, we came up with open-source Python libraries based scalable and computationally efficient solution. In addition, the proposed innovation could generate datasets containing many realizations of CIRs of a LiFi channel by considering user that are either walking or stationary. The mobile terminal orientation is also taken into consideration. Furthermore, this innovation could generate path-loss channel models for Wi-Fi and 5G channels for a given 3D geometrical environment.

Intelligent eAT3S Oracle	**USTRATH**

This innovation targets to enhance the performance of the both the user plane (UP) and core network AT3S functionalities presented by 3GPP in release 16. Accordingly, the proposed enhanced AT3S (eAT3S) oracle agent will have the ability to predict and decide the operation mode, switching, splitting, steering, by simply changing the individual wireless access technology (WAT) weights prior and during transmission. The decision-making agent in our eAT3S oracle is based on the deep reinforcement learning (DRL) algorithm. The environment that the decision-making agent takes actions on could also be a simulation environment, a laboratory testbed and/or a 5G-CLARITY use case. The optimal policy could be achieved when the system throughput for all the users is maximized.

Multi-Policy Scheduler (MPS)	**USTRATH**

The scheduler is proposed to develop artificial intelligence (AI) based algorithms to program resource allocation to multiple tenants sharing the LiFi attocellular networks. It helps to understand the policies and rules that maybe

required in dynamic autonomic resource allocation.	
AI/ML supported flexible intent interpretation	**LMI**
Ericsson in Ireland (LMI) plans to utilize the knowledge gained in 5G-CLARITY to advance technology in a range of areas in telecommunications. AI/ML supported network management provides powerful insights and decision-making capabilities enabling further steps towards network automation.	

3.4 5G-CLARITY exploitable outcomes of type "Demonstrators"

Table 3-4 describes the exploitable outcomes of the type "Demonstrators" within the 5G-CLARITY project.

Table 3-4: Exploitation Outcomes of Type "Demonstrators"

Demonstrator	Owner
UC1: Enabling Enhanced Human-Robot Interaction (Smart Tourism)	**UNIVBRIS, UGR, I2CAT, ACC, PLF, USTRATH**
The Smart Internet Lab of the University of Bristol with the support of partners will integrate, deploy, and demonstrate the benefits of 5G-CLARITY framework to enhance the Human-Robot Interaction. Three narratives will demonstrate the benefits of the proposed framework.	
UC2.1: Alternative Network to Exchange Production Data (Industry 4.0)	**TID, BOSCH, I2CAT, ACC, IDCC, ACC, PLF**
5G-CLARITY UC2.1, 'Alternative Network to Exchange Production Data', is aimed to demonstrate 5G-CLARITY key innovations in improving the in-factory connectivity toward future Industry 4.0 scenario networks. As introduced in D5.1 [7], UC2.1 will be implemented in RBEF (Robert Bosch España Fábrica Aranjuez), a Bosch factory located in Aranjuez near Madrid, Spain. The main objective is to validate the feasibility of replacing current Ethernet wired connections used to connect Manufacturing Execution System (MES) enabled production lines in the factory floor by the combination of wireless technologies proposed in 5G-CLARITY.	
UC2.2: Enhanced AGV Positioning for Intralogistics (Industry 4.0)	**IHP, BOSCH, I2CAT, USTRATH, PLF**
5G-CLARITY UC2.2 aims at enhancing the positioning of an AGV in the shop floor of a Bosch factory described in 5G-CLARITY D2.1 [8]. As introduced in 5G-CLARITY D5.1 [7], 5G-CLARITY UC2.2 will include an AGV operating on a shuttle service between a warehouse and a production shop floor, in RBEF, Bosch factory located in Aranjuez near Madrid, Spain. Since the two ends of the AGV route are located in different buildings, part of the route will be outdoors. However, only the indoor part of the AGV travelling route is within the scope of the 5G-CLARITY UC2.2.	

4 Individual Exploitation Plans

This section introduces the detailed exploitation analysis for each partner category (verticals, vendors and service providers, network operators, small and medium enterprises, academia and research centres). Also, the individual exploitation plan is updated since 5G-CLARITY D6.1[1].

4.1 Verticals

BOSCH Exploitation Plan

As one of the reference companies around the world, the objective for BOSCH is to improve their strong position as innovation leader and increase their market share. Adding the results of 5G-CLARITY project to the BOSCH standard industrial solutions palette should lead to improvements in production, logistic, maintenance and quality methods.

Besides the process improvements, application of the 5G-CLARITY results in the factory will improve the working environment for all workers. For workshop personnel, this means a safer, less physically challenging and more varied -thus interesting- work. For engineers, planners and maintenance personnel, the new work environment will provide additional information and production lines with improved reliability, less production line downtime, and easier to reconfigure.

Initial exploitation stage will be based in the transfer of the knowledge, technologies and machines developed to other BOSCH factories, including factories working in different activity sectors and assembly lines with different characteristics.

The internal exploitation of results makes a better and direct understanding of the technology requirements and cutting-edge technologies by the managers of the BOSCH group. Other BOSCH´s factories for transference will be selected based on objective criteria such as current facilities, AGV availability, etc.

The Bosch group consists of Robert Bosch GmbH and its subsidiaries totalling more than 300 subsidiaries and regional companies in approximately 60 countries, with more than 30,000 researchers and developers in the company's employee roster.

Beyond the internal exploitation, the demonstration of the 5G-CLARITY results in different factories open up new market opportunities.

Other exploitation activities can be listed as follows:

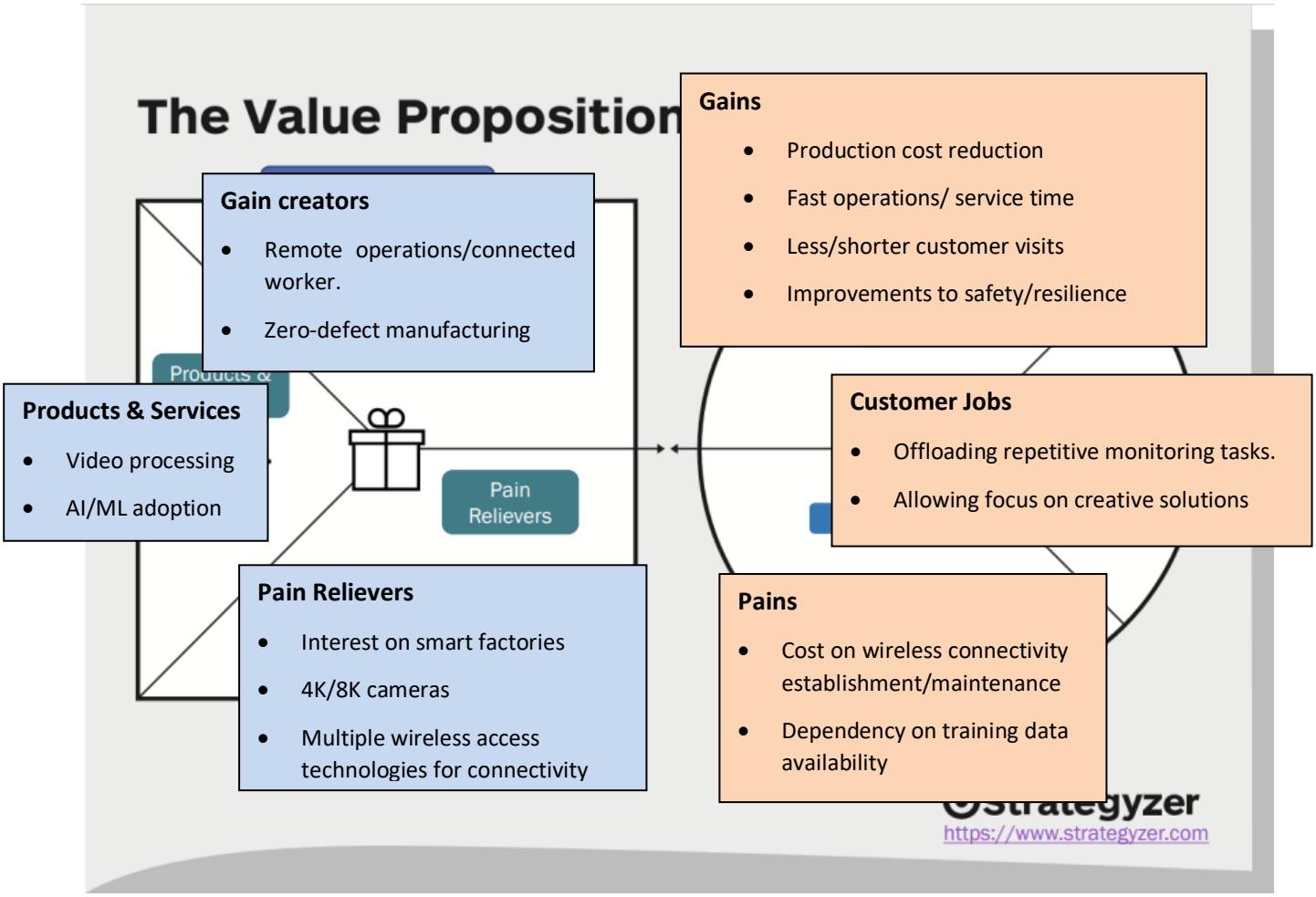
- Further developments, integration into other services.
- Showcase the 5G-CLARITY technologies developed.
- Include acquired know-how for the design of new lines.
- Incorporating results into existing factories of BOSCH partners (customers, suppliers and affiliated companies).
- Background knowledge gained from 5G-CLARITY, national and internal programs. Opening the possibility to launch new RTD project at the cutting edge of the technology. Vendors and service providers

4.1.1 InterDigital

❖ **Exploitable Outcome: Adaptive AI-based defect-detection in a smart factory**

The value proposition delivered by this item is analysed by IDCC and presented in the following VP & Lean

Canvases.


The Value Proposition
Gains
Production cost reduction
Fast operations/ service time
Less/shorter customer visits
Improvements to safety/resilience
Gain creators
Remote operations/connected worker.
Zero-defect manufacturing
Products & Services
Video processing
AI/ML adoption
Pain Relievers
Customer Jobs
Offloading repetitive monitoring tasks.
Allowing focus on creative solutions
Pain Relievers
Interest on smart factories
4K/8K cameras
Multiple wireless access technologies for connectivity
Pains
Cost on wireless connectivity establishment/maintenance
Dependency on training data availability
Strategyzer
https://www.strategyzer.com

<table>
<tr>
<td rowspan="2">PROBLEM
• How to make quality control process faster?
• How to utilize 5G for factories of future – remote connected worker/remote operation capabilities?

EXISTING ALTERNATIVES
Quality control worker checks product, conducts measurements, compares with the reference values.</td>
<td>SOLUTION
• Low-latency and high-definition video streaming and video processing
• AI/ML algorithms to perform defect detection.
• Multi-connectivity and telemetry</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION

Video assistance and augmentation services for remote operation/connected worker to detect defective items in the production line.</td>
<td>UNFAIR ADVANTAGE

AI/ML model training should be done by the experts on any new product/item.</td>
<td rowspan="2">CUSTOMER SEGMENTS
• Vertical industries / smart factories
• Network operators</td>
</tr>
<tr>
<td>KEY METRICS
• Increase the production throughput
• Reduce time for quality control</td>
<td>CHANNELS
• Business-to-business channels
• Marketing departments
• Dissemination activities</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
• Personnel
• HW component
• HW integration
• SW development
• SW maintenance
• Network/connectivity services</td>
<td colspan="2">REVENUE STREAMS
• Platform-as-a-service
• SW maintenance</td>
</tr>
</table>

IDCC Exploitation Plan for this item

Through its participation in 5G-CLARITY, InterDigital Europe Ltd (IDCC) targets the validation through trials of some of its technology innovations spanning across smart multi-connectivity solutions and AI-based platforms. These trials are/will be conducted in internal platform activities and integrated setups with 5G technologies from several partners within the consortium. The use cases and test environments defined by the vertical industry represented in 5G-CLARITY, are envisioned to bring valuable technological and business insights that will pave the way for tangible exploitation of InterDigital's innovations. The exploitation routes foreseen by IDCC include but are not restricted to:

(i) standard essential contributions; and

(ii) pre-commercial proof-of-concepts leading to commercial products.

These exploitation routes will be followed based on two different exploitation models, namely research exploitation model and technological exploitation model. The research exploitation model implies the re-utilization of the research know-how acquired in future research activities. The project results will be exploited as integrating them in the research and/or setting up future research projects further promoting the project results. The technological exploitation model implies the re-utilization of the technological know-how acquired for the standards contribution, development of innovative products and the provision of advanced services built on top of them. The project results will be provided as components/features for know-how transfer in other products/services/standards contributions.

5G-CLARITY has been and will be used to enhance technology solutions/features to provide vertical-specific and mobile network operator-specific requirements. IDCC plans to continue to 5G-CLARITY integrated setup to exploit/showcase real-world trials and demonstrations in live networks with either commercial equipment available on the market or customized equipment provided by the project partners.

Regarding the standard essential contributions, IDCC plans on exploiting the results of 5G-CLARITY by developing essential technologies and contributing these technologies to fill gaps identified in relevant standards such as 3GPP, ETSI, IETF and IEEE. InterDigital, an active contributor in various SDOs (such as 3GPP SA1 and ETSI MEC), will identify gaps in relevant standards that can be filled based on the 5G-CLARITY project results and experimentations.

Regarding the pre-commercial proof-of-concepts, IDCC plans to integrate some of the 5G-CLARITY solutions into Proof-of-Concepts (PoC) which will be demonstrated at relevant exhibitions and conferences, including the Mobile World Congress (MWC) and the European Conference on Networks and Communications (EuCNC). More specifically,

(i) a portable production line platform and robotic application will be enhanced by assessing new hybrid slicing solutions and multi-WAT integration allowing to simultaneously meet high-bandwidth demand and low-latency requirement dictated by such applications; and

(ii) a service on adaptive AI-based defect/obstacle-detection in a smart factory will be enhanced by the 5G-CLARITY multi-WAT integration and PNI-NPN integration to enable video assistance and augmented services for remote operation/connected worker. The AI-based defect/obstacle-detection service will be used to understand or assess performance issues which can be considered as defective item/production throughput in case of defect-detection or considered as route completion time/efficiency in case of AGV to deliver/collect goods from the production lines.

These are meant to support monetization by means of technology licensing or spin-off and joint ventures toward commercial solutions offering.

4.1.2 Ericsson LMI

❖ **Exploitable Outcome: AI/ML supported flexible intent interpretation**

LMI Exploitation Plan for this item

Ericsson in Ireland (LMI) plans to utilize the knowledge gained in 5G-CLARITY to advance technology in a range of areas in telecommunications. AI/ML supported network management provides powerful insights and decision-making capabilities enabling further steps towards network automation.

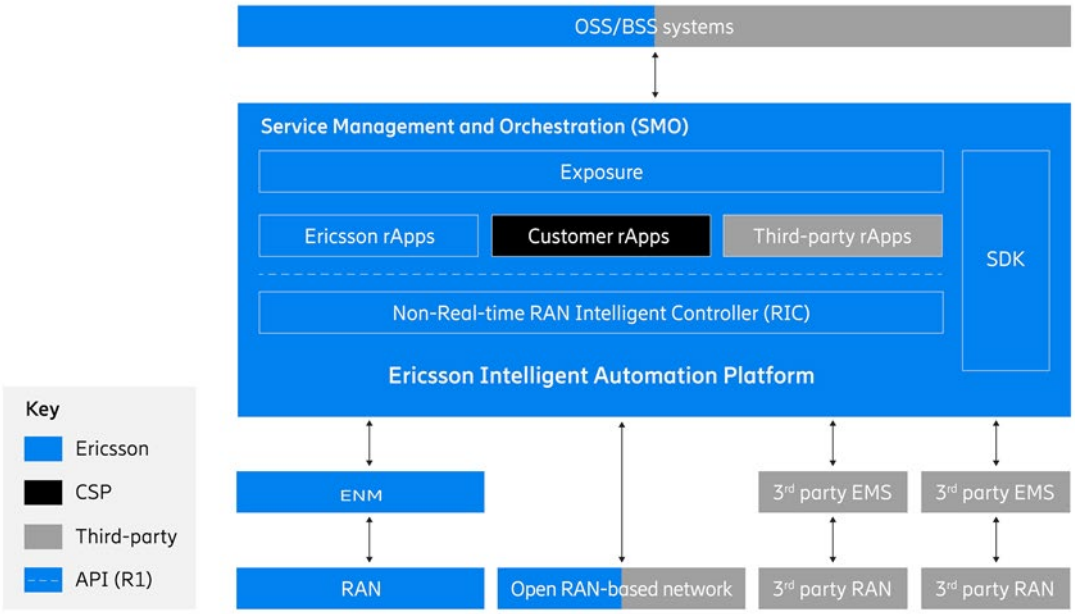


Figure 4-1: Ericsson Intelligent Automation Platform [9]

Automation has become a necessity in network management motivating the utilization of AI/ML paradigms to produce intelligent components (see Figure 4-1)[9]. In the context of the 5G-CLARITY project, LMI has developed an AI/ML supported management component to allow network operators to deploy trained models in their network management scenarios. This tool, referred to as the AI Engine, will be evaluated through its integration and execution in several use cases. The knowledge and experience gained from implementing these scenarios will guide our future implementations in the network automation space.

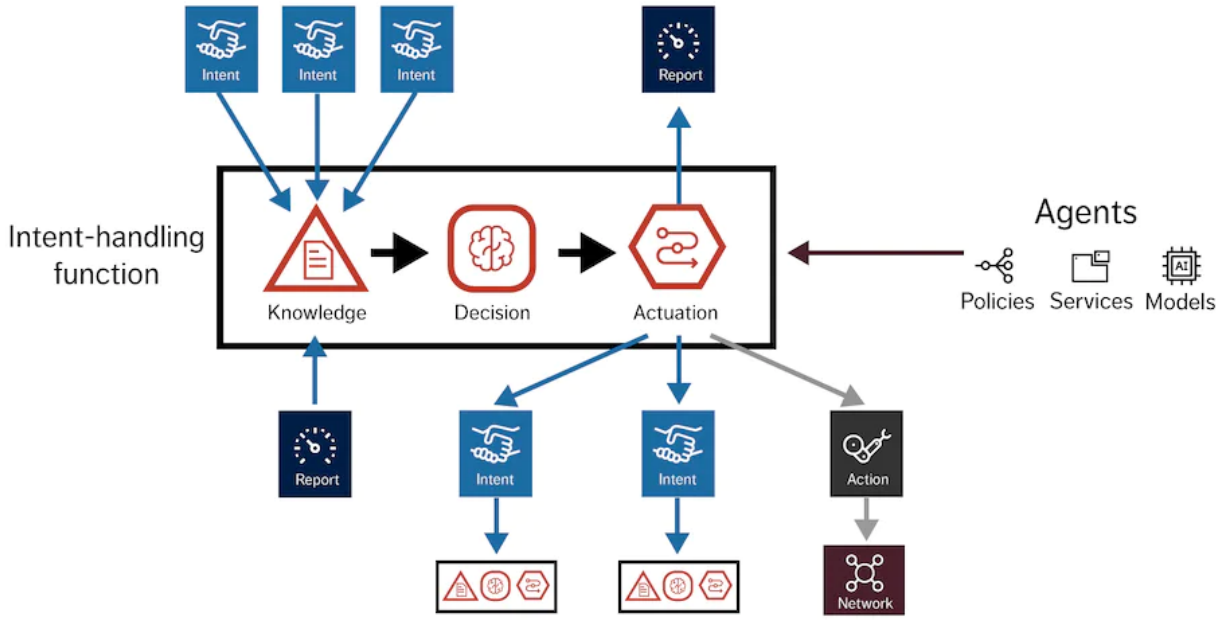


Figure 4-2: The intent-handling function [10]

Intent has become a prevalent concept in the area of network management research, especially in the pursuit of zero-touch and network automation (see Figure 4-2) [10]. LMI has developed an intent translation component, referred to as the Intent Engine, to allow the realization of intents described through natural language. As intent standardization efforts continue, experience in implementing these concepts in modern networks is valuable. The internal exploitation of lessons learned from the 5G-CLARITY UCs will inform future research and experiments.

4.2 Network operators

TID Exploitation Plan

The participation in 5G-CLARITY project represents for TID a great opportunity for the investigation in a multi-provider environment of the evolution towards 'public network integrated non-public network (PNI-NPN) scenarios', which refers to the ability to use the public network in connection with private (non-public) networks, e.g., in-factory networks, campus networks. In particular, TID is using the results from 5G-CLARITY project to identify the technology enablers of selected PNI-NPN scenarios, and assess their capabilities, by means of a techno-economic analysis. Among these capabilities, of special interest are:

- The use of network slicing, as a cost-efficient provisioning solution of PNI-NPN's
- The use of data semantic fabric, to consolidate model-based telemetry approach, that we will believe will constitute an essential component of future 5G infrastructure management to provide a better support for evidence-enabled automation (based on analytics, AI, etc.) and even as part of the service portfolio to be provided to B2B customers. These customers may make use of this data semantic fabric to aggregate data from PLMN and on-site infrastructure nodes, consolidating these data for E2E service view and associated monitoring (e.g., SLA assurance related) activities.
- The use of mediation function, as a way to make network capabilities made available for consumption in a controlled, secure and auditable way. The exposure of these network capabilities,

which is needed for the E2E service operation in PNI-NPN scenarios, is achieved with the use of open APIs.

As the research and innovation branch of the Telefónica Group, TID follows two main tracks to maximize the beneficial impact of the participation in 5G-CLARITY project on the listed technology capabilities.

The first track is related to **knowledge transfer**, towards the different areas of the Telefonica Group, including 1) global areas, e.g. Telefónica Tech, Telefónica Infra; 2) local operators, e.g., Movistar, Vivo, O2, Virgin-O2; and 3) other partners in the company's innovation ecosystem, especially those entrepreneurs collaborating with Telefónica through initiatives like WAYRA [11]. TID provides these Telefónica areas with the technology base and experience for the design and development of advanced services benefiting from 5G-CLARITY outcomes for the commercial market, with a focus on managed PNI-NPN solutions. On the way to this knowledge transfer, TID team organizes periodic seminars and workshops, and disseminates TID activities in 5G-CLARITY (technology contributions, project deliverables and events, etc.) through internal corporate channels.

The second track is on the **influence on the evolution of the technology,** which is a very valuable exploitation result in projects of this nature. The early understanding of the available technology options and their analysis with involved corporate units and relevant customers allows Telefónica Group to foster the adoption and further standardization of those solutions best fitted to the requirements of our customers, and to impact the priorities of the standardization process (as we have done in 3GPP SA5 and ETSI ZSM, with quite a high number of contributions regarding operational aspects of non-public networks). In a sector so dependent on standardization, and on the regulations based on these standards, this constitutes an asset of high value.

❖ **Exploitable Outcome: APIs enabling network capability exposure in PNI-NPN scenarios**

TID Exploitation Plan for this item

Heavy Reading has recently released a report, where operators are asked to specify by when they expect the private 5G market to take-off.

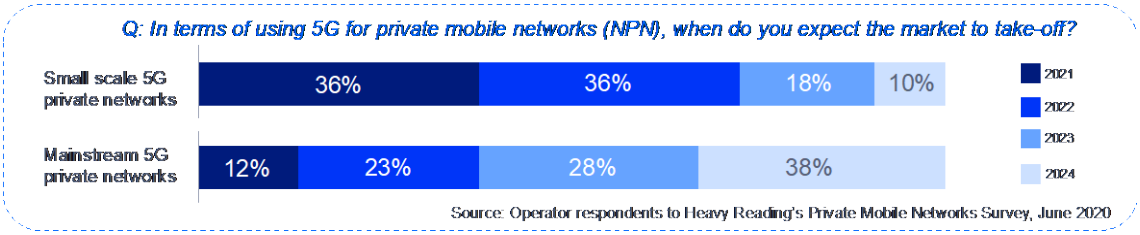


Figure 4-3: Heavy's Reading Private Mobile Networks Survey

Having a look at the results shown in Figure 4-3, it is clear that standalone NPNs will be the first ones to be commercialized. 5G innovation here is relatively easy, since there is almost no legacy. However, having greenfield environments does not mean low cost, but just the opposite. The fact that customized 5G networks need to be setup for very specific customer makes CAPEX and OPEX quite high, making this option only affordable by large-sized companies.

However, as the 5G technology matures, the transition from isolated private networks to PNI-NPNs will be reality. This will allow deploying private 5G networks at large scale, dramatically reducing costs and making them affordable for most of customers. The cost savings do not only account for CAPEX, but also for OPEX (i.e., the customers offload complex operational issues to the MNO, putting all the efforts on their business, focusing on service innovation and process innovation) while allowing for reduced time-to-market. For further details, see Figure 4-4.

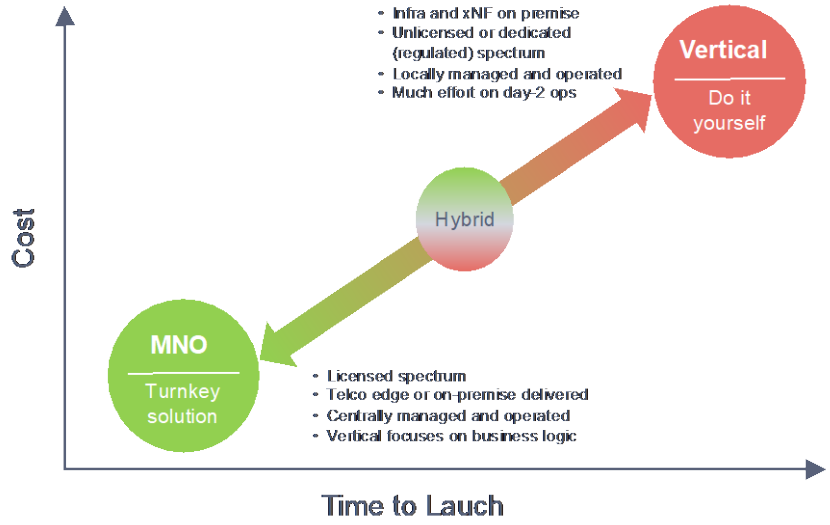


Figure 4-4: PNI-NPN – Time to market vs Cost

According to the above rationale, it is clear that the preferred solution in the long run is PNI-NPN.

As the research and innovation branch of a Tier-1 CSP, TID is evaluating how to best apply the PNI-NPN concept explored in 5G-CLARITY to evolve the capabilities of current Telefónica's network and IT assets. These capabilities, which include infrastructure, data and orchestration capabilities, will be combined to deliver managed solutions for the provisioning and operation of managed PNI-NPN solutions. Targeted customers for these solutions belong to B2B/B2B2C market. Examples of these customers include:

- Baseline vertical customer (B2B market): a customer with no telco experience, which is only interested in monitoring the provided PNI-NPN, to verify it behaves as expected, according to the SLA. The capabilities offered to a baseline vertical customer includes the ability for this customer to receive information on subscribed items, including network status (e.g., active, inactive) and subscribed management data (e.g., KPIs, events/logs, trace data, etc.). The profile of this customer type is a 'passive customer'.

- Advanced vertical customer (B2B/B2B2C market): Unlike the baseline vertical customer, this new NSC does typically have (yet limited) telco knowledge, and wants to retain certain control over the allocated PNI-NPN. The capabilities offered to an advanced vertical customer might include (i) monitoring capabilities, i.e., the same capabilities offered to a baseline vertical customer; and (ii) device configuration capabilities, i.e., provision of parameters for battery, mobility and communication patterns associated to the device; (iii) edge discovery/selection, e.g., in case the vertical want to deploy workloads on the telco edge cloud.

- Hyperscaler (B2B2C market): requests for PNI-NPN to provide service-tailored connectivity pipe to their final enterprise customers. With some enterprises (i.e., hyperscaler's customer) starting to migrate workloads towards hyperscaler nodes, it is necessary for the hyperscaler (MNO's customer) to provide SLA guarantees to these enterprises, especially for critical processes/services. However, the hyperscaler does not have network resources between its cloud nodes and customer premises, and therefore to ask the mobile network operator (i.e., CSP) to set up a PNI-NPN between these endpoints. The capabilities offered to an hyperscaler might include (i) monitoring capabilities, i.e., the same capabilities offered to a baseline vertical customer; (ii) quality on demand, i.e., dynamic QoS and bandwidth management; (iii) policy control, i.e. influence on traffic routing.

- Mobile virtual network operator (B2B2C market).

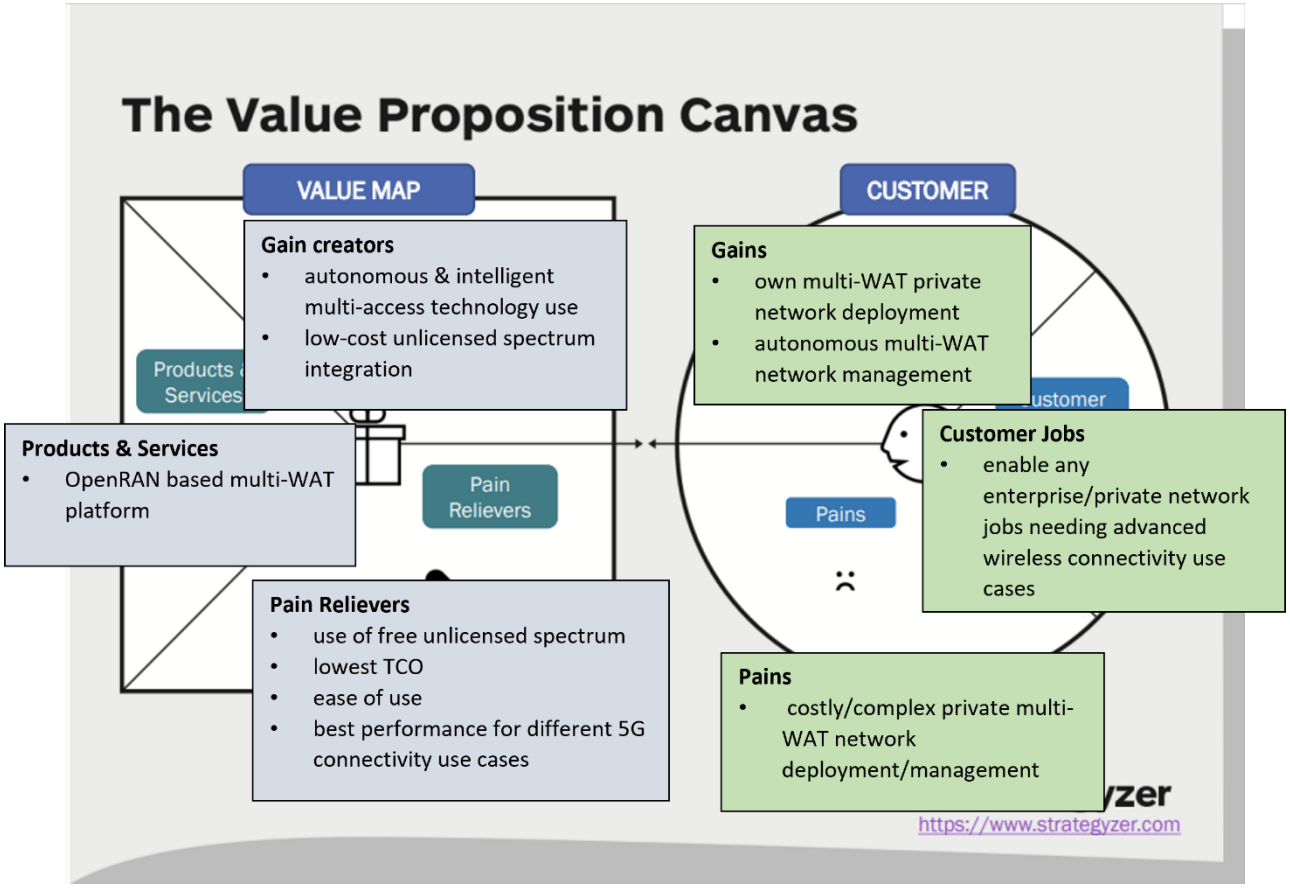
To satisfy the needs for all these customers, it is needed for Telefónica to offer abovementioned network capabilities from PLMN. The on-demand, secure and controlled (auditable) exposure of these network capabilities to 3rd parties may be a relevant opportunity for Telefónica, and one of the main ways to monetize investment in fibre, edge computing and 5G. To ensure wide market adoption and an attractive economy of scale for operators and their customers, it essential to push the industrialization of open, global and interoperable APIs for network capability exposure. In this regard, Telefónica in cooperation with other industry partners (operators, vendors, hyperscalers, developers and system integrators) has constituted an open-source initiative to foster the definition, development, testing and validation of APIs, in PNI-NPN scenarios. Telefónica leverages outcomes from 5G-CLARITY to propose API specifications and validate them in their lab facilities with 5G assets (through test campaigns), before getting these APIs certified and moved to production networks. These contributions are led by the TID team.

4.3 Small and medium enterprises

4.3.1 Accelleran

❖ **Exploitable Outcome: Multi wireless access technology (4G/5G/WiFi/LiFi) open RAN with AI/ML xApps**

The value proposition delivered by this item is analysed by ACC and presented in the following VP & Lean Canvases.



<table>
<tr>
<td rowspan="2">PROBLEM
• Complexity of network deployment
• high CAPEX of network
• high OPEX of network

EXISTING ALTERNATIVES
only WiFi in the private network or MNO-lead integration</td>
<td>SOLUTION
use intelligence to configure and optimise multi-WAT network</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION
/</td>
<td>UNFAIR ADVANTAGE
/</td>
<td rowspan="2">CUSTOMER SEGMENTS
• private enterprises
• MNOs

EARLY ADOPTERS
innovative companies trying to increase productivity</td>
</tr>
<tr>
<td>KEY METRICS
/</td>
<td>CHANNELS
• System integrators
• neutral hosts</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE

/</td>
<td colspan="2">REVENUE STREAMS

licenses and royalties</td>
</tr>
</table>

ACC Exploitation Plan for this item

In general, Accelleran as SME exploits the results of the research projects by accelerating its solution roadmap, enhancing the functionality or increasing the TRL of their solution offerings. In 5G-CLARITY case Accelleran will exploit the enhancements made in the project from their current neutral-host enabled cloud-native 4G dRAX commercial offering towards an Open and Disaggregated RAN neutral-host enabled cloud-native multi wireless access technology (4G/5G/WiFi/LiFi) dRAX RIC platform enabling support for intelligent AI/ML xApps. The exploitation of this enhanced commercial dRAX offering will be done based on:

- Revenue from the technology access fees/software licenses/maintenance& support/royalties of a 4G/5G (and potentially also 4G/5G/WiFi/LiFi) OpenRAN offering to:
    - Tier 1 MNOS
    - Tier 2/3 MNOs, System Integrators and Towercos
- Private Enterprises/Vertical markets enabled with 5G
- Revenue from shared portfolio of 3rd party xApps developed on top of dRAX platform

4.3.2 Gigasys Solutions

GIGASYS is an SME on wireless consultancy and project management in the area of collaborative R&D in ICT. GIGASYS will use selected 5G-CLARITY results for strengthening its consulting competency and to deliver value to its clients in the telecommunications industry across Europe. The exploitation of 5G-CLARITY results by GIGASYS follows a three-step process:

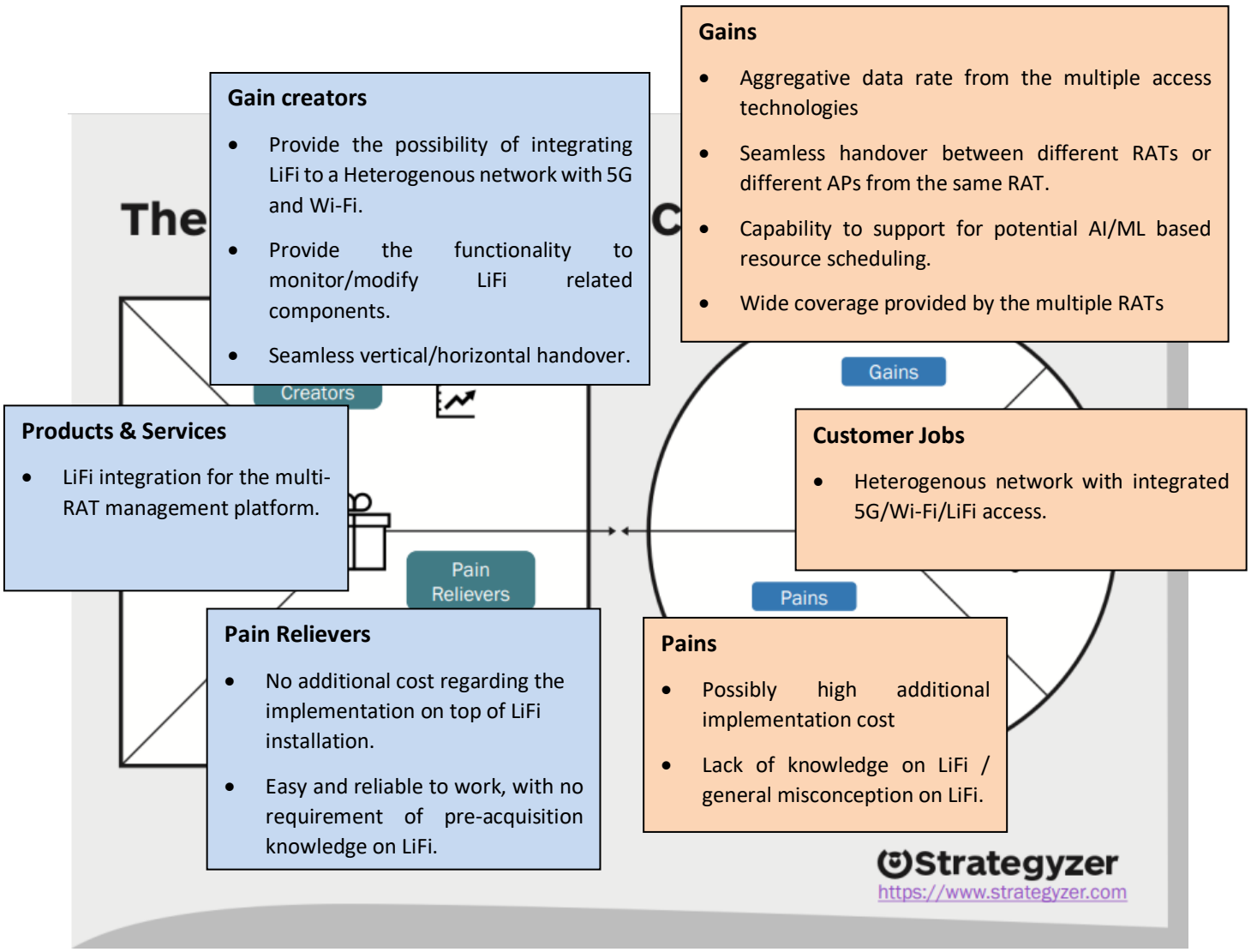
- Identification of exploitable project results on a continuous basis by GIGS' key personnel.
- Generation of White Papers and other information items based on the identified exploitable project results.
- Value creation for clients through discussions, follow-up research and innovation as well as consulting on emerging networks, services, and applications related to the identified exploitable project results.

In particular, GIGASYS will advise its telco clients and partners via bi- and multi-lateral exchanges, targeted workshops, and community-internal White Papers. Furthermore, GIGS will use 5G-CLARITY results to advise its clients on opportunities and risks arising from 5G-CLARITY results and the impact they may have.

4.3.3 pureLiFi Ltd

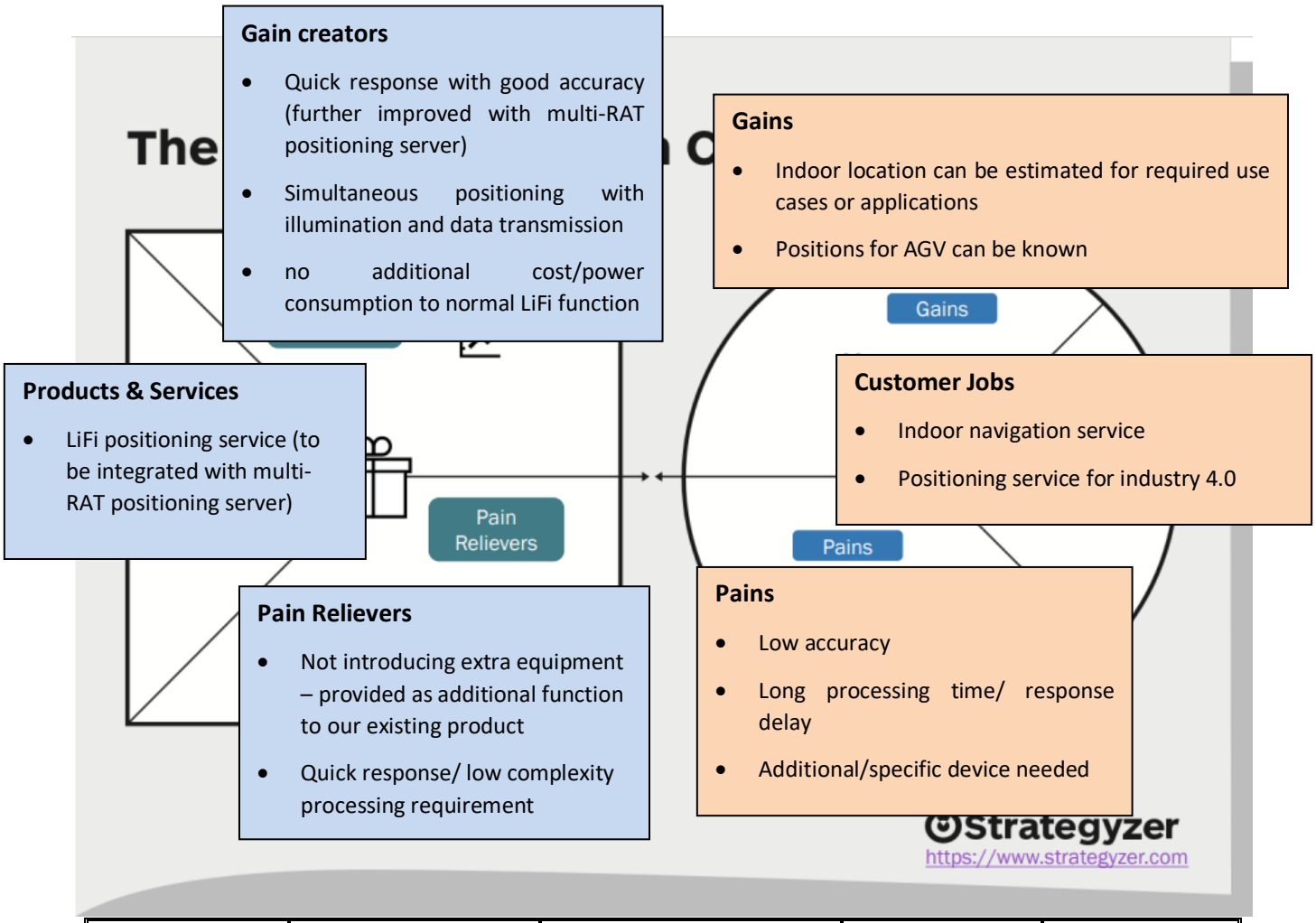
- **Exploitable Outcome: LiFi integration for the multi-RAT management platform**
- **Exploitable Outcome: LiFi positioning system**

The value proposition delivered by these two items are analysed by PLF separately and presented in the following VP & Lean Canvases – firstly for **LiFi integration for the multi-RAT management platform;** then for **LiFi positioning system**


Gain creators
Provide the possibility of integrating LiFi to a Heterogenous network with 5G and Wi-Fi.
Provide the functionality to monitor/modify LiFi related components.
Seamless vertical/horizontal handover.
Gains
Aggregative data rate from the multiple access technologies
Seamless handover between different RATs or different APs from the same RAT.
Capability to support for potential AI/ML based resource scheduling.
Wide coverage provided by the multiple RATs
Creators
Gains
Products & Services
LiFi integration for the multi-RAT management platform.
Customer Jobs
Heterogenous network with integrated 5G/Wi-Fi/LiFi access.
Pain Relievers
Pains
Pain Relievers
No additional cost regarding the implementation on top of LiFi installation.
Easy and reliable to work, with no requirement of pre-acquisition knowledge on LiFi.
Pains
Possibly high additional implementation cost
Lack of knowledge on LiFi / general misconception on LiFi.
Strategyzer
https://www.strategyzer.com

<table>
<tr>
<td rowspan="2">PROBLEM
• Multiple separate networks to work with
• different SSIDs for each RAT
• have to switch manually between RATs
• bad handover experience.

EXISTING ALTERNATIVES
• No mature market for LiFi technology yet. Most LiFi products are working stand-alone
• Some research efforts on SDN based hybrid LiFi/Wi-Fi networks.</td>
<td>SOLUTION
LiFi integration for the multi-RAT management platform as an additional function to the existing product</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION
Integrate LiFi with 5G/Wi-Fi heterogenous network</td>
<td>UNFAIR ADVANTAGE
LiFi related development is based on our own product LiFi-XC.</td>
<td rowspan="2">CUSTOMER SEGMENTS
Existing customers as this is an additional function to the product</td>
</tr>
<tr>
<td>KEY METRICS
• Observe if LiFi related telemetry data is correctly generated and delivered.
• Packet loss rate
• Responding time</td>
<td>CHANNELS
Use case studies
marketing departments</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
• Personnel
• SW development
• Network services</td>
<td colspan="2">REVENUE STREAMS
Products/Services</td>
</tr>
</table>



PROBLEM	SOLUTION	UNIQUE VALUE PROPOSITION	UNFAIR ADVANTAGE	CUSTOMER SEGMENTS
Positioning service for indoor scenario including industry 4.0	• LiFi positioning service on top of our product • Be part of the multi-RAT positioning server which includes multiple technologies for	• This developed LiFi positioning service is provided as an additional to our existing product. No extra hardware equipment required nor extra power	Developed on top of our own product.	Currently targeting to existing customers and use cases as a provided additional function to the

<table>
<tr><td rowspan="2">EXISTING ALTERNATIVES
Indoor location service with single technology</td><td>high performance</td><td rowspan="2">consumption.
• Would be integrated to the main multi-RAT based positioning server for an overall high accuracy positioning service. Will be demonstrated for Industry 4.0 use case.</td><td></td><td rowspan="2">product.</td></tr>
<tr><td>KEY METRICS
• Response time
• Accuracy</td><td>CHANNELS
• Use case studies
• Marketing department</td></tr>
<tr><td colspan="3">COST STRUCTURE
• Personnel
• SW development
• System validation</td><td colspan="2">REVENUE STREAMS
Products/Services</td></tr>
</table>

PLF Exploitation Plan for these two items

According to Figure 4-5 [12], LiFi market size exceeded USD 70 million in 2019 and is poised to grow at a compound annual growth rate (CAGR) of over 50% between 2020 and 2030. Increasing utilization of connected devices in business establishments has led to a growing demand for indoor distributed networks. The ability of LiFi to transfer high volumes of data without any interference from existing radio frequencies will augment the market demand. As a global leader in LiFi technology, pureLiFi sees the opportunity and will explore actively to align its strategies and marketing.

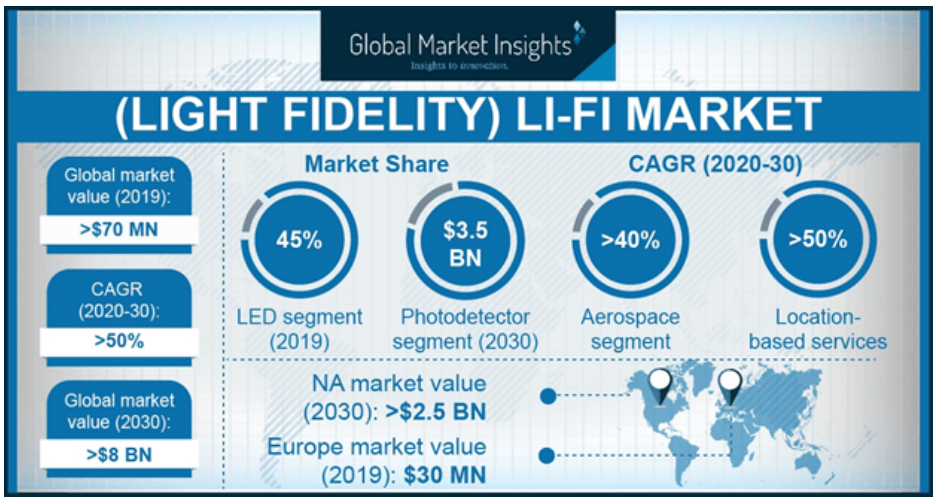


Figure 4-5: LiFi market estimation by Global Market Insights

pureLiFi is a regular participant to standardisation activities and chairs IEEE802.11bb task group (TGbb) which is LiFi focused. This is expected to drive forward the global standardisation efforts for light communications with manufactures, operators and end customers all present during the standardisation process.

pureLiFi is founding member of the Light Communication Alliance (LCA) alongside industry leaders such as NOKIA, Du Telecommunications, and Liberty Global. The LiFi ecosystem is shown in Figure 4-6 [13], and pureLiFi intends to exploit and build important business alliances.

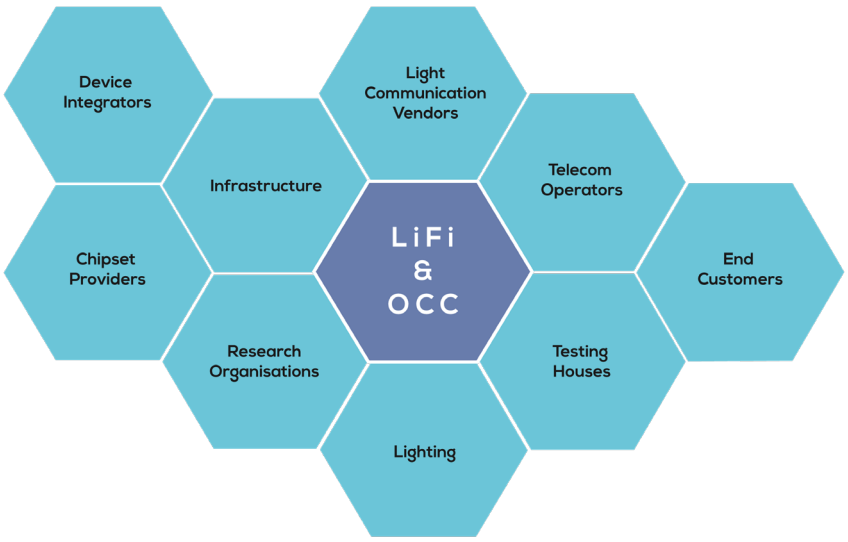


Figure 4-6: LiFi Ecosystem [13].

For LiFi integration for the multi-RAT management platform

Light communication technologies complement and enhance 5G wireless communications and other radio frequency technologies such as Wi-Fi. It's expected that LiFi will sync with 5G in the next several years as shown in Figure 4-7. 5G-CLARITY use-cases are key scenarios for integrating LiFi technology to the fabric of 5G systems.

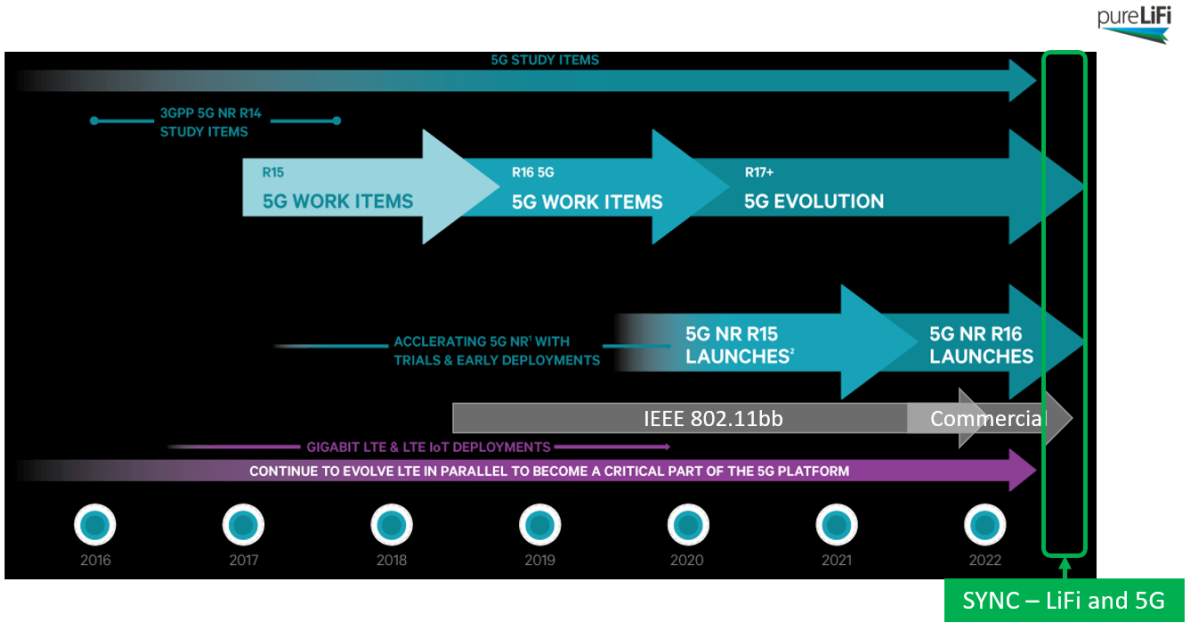


Figure 4-7: 3GPP Rev.15 and Rev.16 timeline (Qualcomm) and LiFi timeline

European operator O2 has kicked off a trial that involves sending large amount of data using LiFi [14]. As part of the trial, O2 has installed PLF's LiFi-XC system, comprising of nine LiFi-enabled LEDs, in the 'Explore Room' of its Slough HQ. It shows that the LiFi system can be integrated to 4G, 5G core network and extends wireless communications beyond Wi-Fi and Cellular networks. The innovate development of the LiFi integration for the multi-RAT management platform will improve our current product by enhancing the capability and performance of integration with 5G and Wi-Fi technologies. PLF will exploit this development for both existing use-cases/customers and further potential opportunities.

For LiFi positioning system

The global indoor location market size is expected to grow from USD 7 billion in 2021 to USD 19.7 billion by 2026, at a CAGR of 22.9% during the forecast period as shown in Figure 4-8 [15]. Currently LiFi based positioning techniques have attracted many attentions and research efforts. There are several approaches for LiFi based location system including the ones based on received signal strength (RSS), angle-of-arrival (AOA), and time-of-arrival (TOA), as well as LiFi specific ones with multi-directional receivers and transmitters.

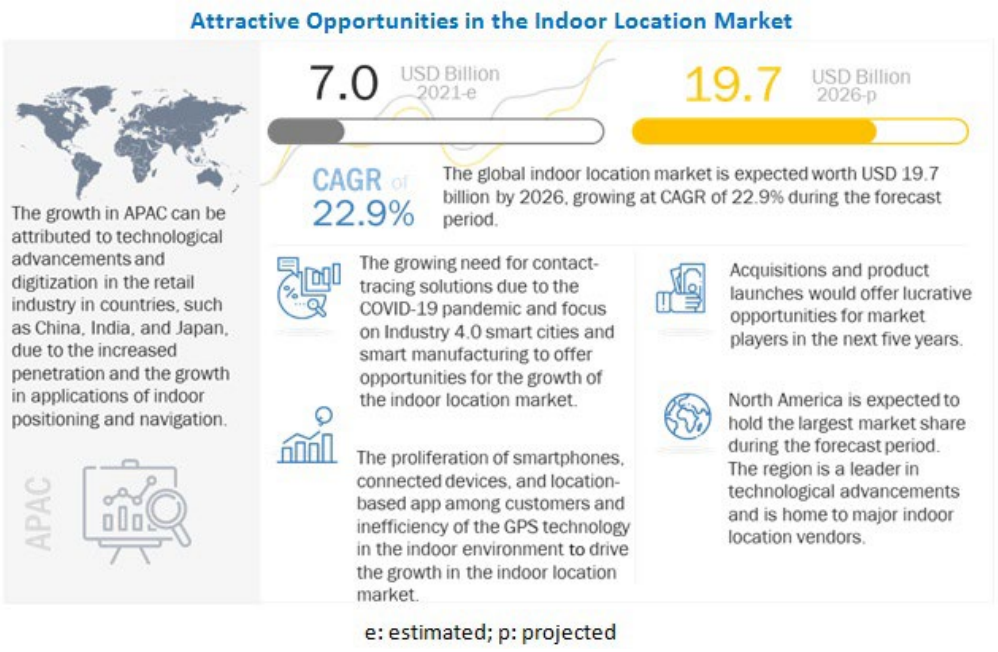


Figure 4-8: Forecast of Indoor Location Market.

The LiFi positioning system developed by PLF within 5G-CLARITY provides additional function to the existing product. Instead of developing stand-alone LiFi positioning system, we build on top of our LiFi-XC product with the capability of calculating RSS values from multiple APs and estimate the user location accordingly. Again, this exploitable outcome is another additional value point for our existing product. The outcome will be exploited with our existing use-cases and customers as an additional function. Regarding the potential use case for this LiFi positioning system, one for Health & Care indoor navigation as shown in Figure 4-9 would fit for both data communication and location service.

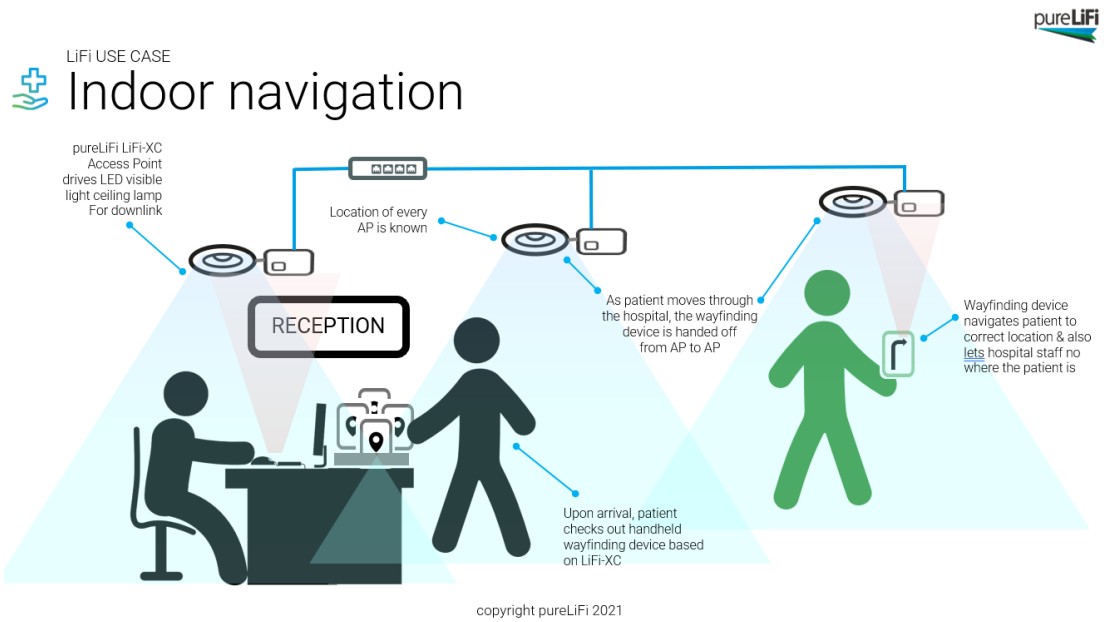


Figure 4-9: LiFi use case for Indoor navigation

4.4 Academia and research centres

4.4.1 University of Granada

Exploitable Outcome: Kernels 5.4 and 5.5 binaries and sources with MPTCP with a Weighted Round Robin scheduler and API

UGR Exploitation Plan for this item

MPTCP support for Linux Kernels above 4.19 based on [16] implementation was not available at the beginning of the project, UGR team adapted it so it could be used within the project's CPE. The binaries for versions 5.4 and 5.5 are published as .deb packages at https://github.com/jorgenavarroortiz/5G-CLARITY_testbed_v0/tree/main/vagrant/vagrant, for x86 and ARM architectures (such as Raspberry Pi 3). These kernels were tested so the wireless interfaces for WIFI 6 provided a high performance. These implementations, and the documentation provided along the binaries, may facilitate the adoption of MPTCP in modern Linux boxes, leveraging the use and development of applications which may take advantage of the sharing of multiple network interfaces.

Additionally, the binaries with the 5G-CLARITY scheduler implementation for MPTCP, a Weighted Round Robin scheduler (WRR), has been provided along with the previous kernels. This scheduler allows the designing and deployment of more controlled transport layer services to take the most of each available interface. This implementation should provide better performance than the Round Robin scheduler for interfaces with different characteristics.

The source code of the WRR will be provided along the binaries after evaluating its performance in the 5G-CLARITY testbeds.

To allow the design of intelligent transport layer's services, we have developed an API which facilitates the remote control of the MPTCP schedulers' parameters. This API will permit machine learning (ML) frameworks to extract state information from the MPTCP socket, as well to launch MPTCP related actions from ML models. This will ease the application of ML to this kind of network operations.

- **Exploitable Outcome: dRAX plugin to gather MPTCP telemetry**

UGR Exploitation Plan for this item

The API developed to access to the state information of the MPTCP schedulers allows to implement a probing module which can be called by a dRAX server. To that end, a dRAX plugin for gathering the telemetry of an open MPTCP socket will be implemented. This plugin will allow administrators and developers to use remote information of MPTCP based services to (re)configure and take RAN related actions to improve the performance of the wireless networks.

- **Exploitable Outcome: Virtualized multi-connectivity framework**

UGR Exploitation Plan for this item

The virtual testbed developed for the 5G-CLARITY's multi-connectivity framework will allow other implementors and researchers on 5G with multi-connectivity support to boost their designs.

- **Exploitable Outcome: 5G-CLARITY multi-WAT scheduler**

UGR Exploitation Plan for this item

This scheduler allows the designing and deployment of more controlled transport layer services to take the most of each available interface. This implementation should provide better performance than the Round

Robin scheduler for interfaces with different characteristics. Its API may allow the rapid development of ML based models for controlling and adjusting traffic between different wireless links.

- **Exploitable Outcome: Deep Reinforcement Learning (DRL)-assisted solution for resource partitioning in a multi-technology Radio Access Network (RAN)**
- **Exploitable Outcome: Deep Reinforcement Learning (DRL)-assisted solution for dynamic transport network setup and computing resources provisioning**

UGR Exploitation Plan for these two items

Private 5G networks are sophisticated systems that offer a high configuration flexibility. Because of this flexibility, the optimization problems for configuring these networks easily become intractable, i.e., exact methods (e.g., analytical optimization techniques) cannot solve them within a reasonable period of time. In this vein, Machine Learning techniques are appealing to assist the configuration of these networks. Indeed, several reports support the adoption of Artificial Intelligence (AI)-based solutions in many vertical use cases for the sake of automation, efficiency, and performance enhancement. By way of illustration, a report made by Markets and Markets forecasts the global AI market size to grow from USD 58.3 billion in 2021 to USD 309.6 billion by 2026, at a Compound Annual Growth Rate (CAGR) of 39.7% during the forecast period [17]. On the other hand, Grand View Research report [18] highlights that the global AI market size was valued at USD 62.35 billion in 2020 and is expected to expand at a CAGR of 40.2% from 2021 to 2028.

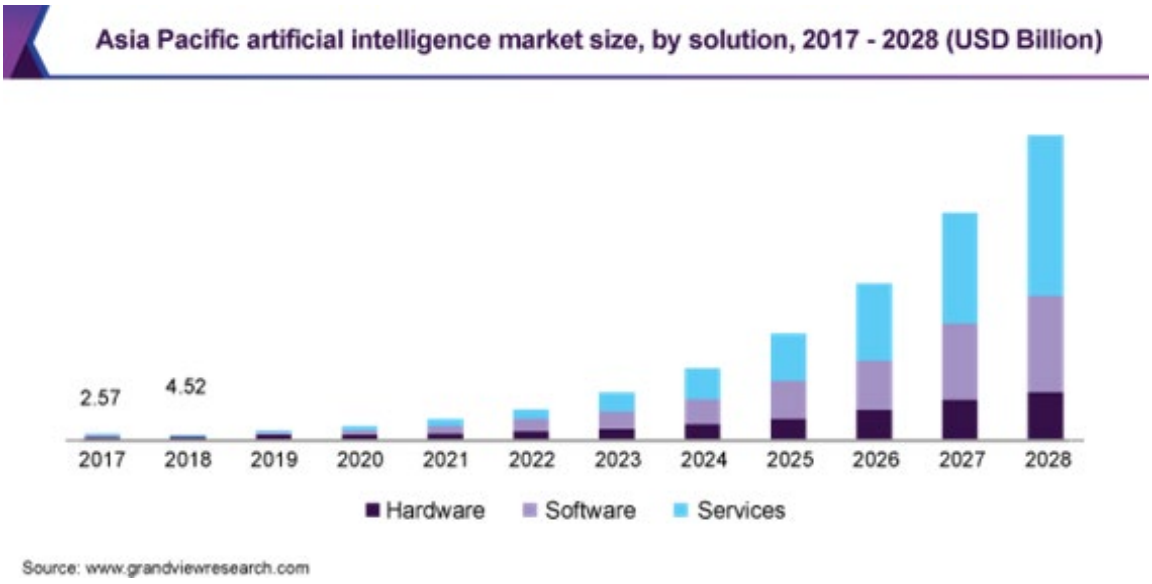


Figure 4-10: Global AI market size growth estimation

In short, several factors such as the technological enhancement and complexity, and the growth of the data bases size push the adoption of AI-based solutions.

AI engines enable to host multiple AI-assisted algorithms for configuring, controlling and managing 5G systems. In the 5G-CLARITY system, the interface between the algorithms and the private 5G network is the intent engine, which enables the operator to easily configure the policies and optimization objectives of the algorithms. In turn, it also provides the algorithms with the required telemetry data for their operation.

A set of Reinforcement Learning (RL)-based algorithms for configuring the different segments of the network are developed within the 5G-CLARITY project to automate the configuration of the different segments of the network (e.g., Radio Access Network –RAN-, transport network –TN-, and computing domain). The algorithms leverage analytical performance models to speed up the RL agents training process, the feasibility

check of the actions issued by the agent, i.e., to filter those actions that do not meet any optimization constraint (e.g., 5G streams performance requirements), and estimate performance measurements that are not available (e.g., worst-case end-to-end delay and jitter).

To date, RL-based algorithms for the resource allocation in multi-Wireless Access Technology RANs and the configuration of asynchronous Time-Sensitive Networking (TSN) networks are under development. On the one side, the former enables the dynamic radio resource provisioning in RAN comprising Wi-Fi and 5G New Radio (NR) technologies for the ongoing 5G-CLARITY slices. On the other side, the latter aims to find satisfiable configurations for an asynchronous TSN-based TN, e.g., prioritization and shaped queues assignment for the ongoing 5G-CLARITY slices.

The UGR´s exploitation plan regarding these ML-based algorithms comprises the generation of high impact scientific publications describing the key findings, results, and contributions.

- **Exploitable Outcome: Potential Game-based method for computing wireless quota of GBR services in RAN slicing**

UGR Exploitation Plan for this item

5G networks aim to boost the digital transformation of industry verticals. These verticals may bring a wide variety of unprecedented communication services with diverging performance requirements. To economically deploy these communication services, network slicing has emerged as a technological solution. This solution consists of providing multiple and logically separated networks, denominated network slices, each tailored to the requirements of a specific communication service over a common physical network infrastructure.

Rising demand for 5G network slicing will drive the market growth. For instance, according to the Global Market Insights, network slicing market size exceeded USD 200 million in 2019 and is estimated to grow at a CAGR of over 15% from 2020 to 2026 [19].

Figure 4-11: Global market insight report

Furthermore, network slicing is expected to address the need for critical wireless communication for industrial operations, public safety, and/or critical infrastructure connectivity. Focusing on the industry, the global market is primarily driven by the growing need for ultra-reliable low-latency connectivity for Industrial Internet of Things (IIoT) applications, including collaborative robots, industrial cameras, and/or industrial sensors. Many of the networks of these industrial use cases are expected to be private networks, that is, networks intended for the exclusive use of an enterprise customer. Based on that, it is expected that 5G

Mobile Network Operators (MNOs) provides customized network slices for such enterprise customers over their private infrastructure and/or the MNO's infrastructure.

Increasing the demand for 5G private networks will also drive the market growth. By way of illustration, the Grand View Research reports [20] highlights that the global private 5G network market size was valued at USD 1,224.3 million in 2020 and is expected to witness compounded annual growth rate (CAGR) of 39.7% from 2021 to 2028.

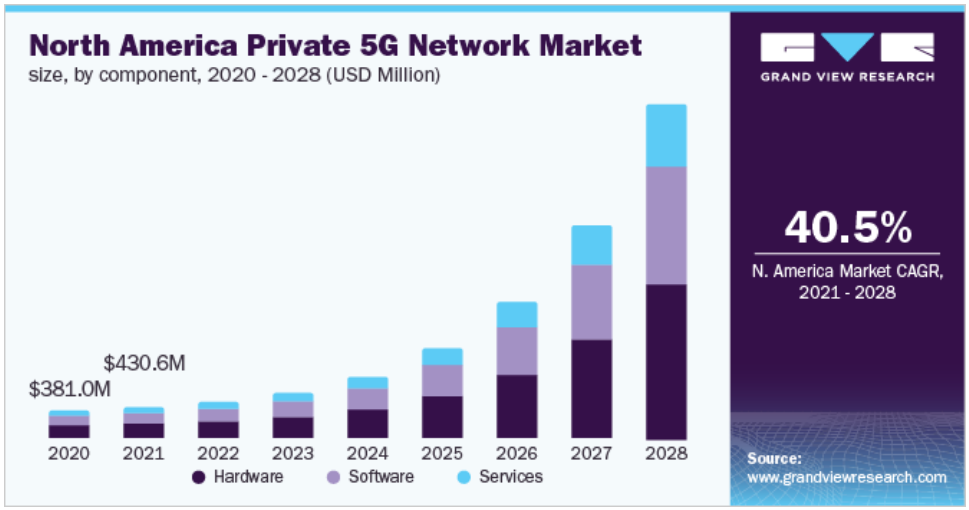


Figure 4-12: Global private 5G network market size estimation

The 5G-CLARITY project has proposed a technological solution to deploy and operate E2E network slices over private and/or public network. Focusing on the RAN, the 5G-CLARITY project has proposed the definition of resource quotas per RAN slice. These quotas allow to guarantee the performance requirements of those network slices which are deployed in a private venue throughout their lifetimes; and limit the maximum radio resources allocated to them.

These quotas must be established when these network slices are planned (i.e., much before deploying these network slices). The 3GPP has also recently defined in [21] a similar concept to the resource quota defined by 5G CLARITY project. However, they do not specify how these quotas may be computed. Some research works also assume the existence of these quotas in their proposals to dynamically allocate radio resources among multiple RAN slices. However, they assume these quotas are conservatively established before deploying the RAN slices.

To shed light on the establishment of these resource quotas, the UGR team has proposed a game theory-based solution to compute the radio resource quotas for multiple RAN slices which accommodates specific communication services with requirements in terms of Guaranteed Bit Rate (GBR). Specifically, the UGR's solution allows to plan the deployment of multiple RAN slices to (a) meet their GBR requirements throughout their lifetime, and (b) guarantee the probability of blocking user sessions in these RAN slices is below a certain threshold.

The UGR´s exploitation plan regarding the computation of resource quotas comprises the generation of high impact scientific publications with the most relevant contributions and results.

4.4.2 University of Strathclyde

- **Exploitable Outcome: MPTCP testbed REST-API**
- **Exploitable Outcome: OWCsimPy**
- **Exploitable Outcome: Intelligent eAT3S Oracle**
- **Exploitable Outcome: Multi-Policy Scheduler (MPS)**

USTRATH Exploitation Plan for these items

Through its participation in 5G-CLARITY, USTRATH targets the implementation/integration of LiFi networks in mature radio frequency (RF) dominated 5G networks to enhance the system capacity, power efficiency, deployment ease and security. Furthermore, cutting edge machine learning (ML)/artificial intelligence (AI) algorithm development for smart radio resource management (RRM) and PHY layer protocol optimization are also envisaged to be designed, validated, and realized during the lifetime of the project. The exploitation routes for USTRATH follows research and technological exploitation model. In research exploitation, the research and development activities are re-utilized to acquire the related know-how. Similarly, the technological exploitation model requires the re-utilization of the technological know-how acquired from the testbed, prototype, and product development. USTRATH plans to continue to be involved in know-how generation along with the testbed/prototype development for the use cases, by using commercially available and in-house custom-made solutions. Some of these solutions will be provided by the other partners during the lifetime of the project.

In terms of the pre-commercial proof-of-concept (PoC) elements, USTRATH plans to exploit the results of essential technologies developed during the lifetime, which will be detailed in the following sections of this document. Accordingly, the simulation, testbed and prototype-based development is planned to be demonstrated in the area specific conferences/workshops. Furthermore, the initial results will also be presented in the deliverables as well as the prestigious IEEE conference and journal publications. More specifically, the following works listed in Table 4-1 are submitted/presented in IEEE conference proceedings.

Table 4-1: USTRATH submitted/presented publication

Paper Title	Authors	Conference/ Journal Name	Publication Date
Dynamic LiFi Attocellular Networks Slicing for 5G Services	Hamada Alshaer and Harald Haas	ICC 2022	Submitted
Synthetic LiFi Channel Model Using Generative Adversarial Networks	Ardimas Andi Purwita, Anil Yesilkaya, Harald Haas	ICC 2022	Submitted
An Optimal Networked LiFi Access Point Slicing Scheme for Internet-of-Things	Hamada Alshaer, Harald Haas, Oluwatayo Y Kolawole	ICC 2021	09-Jul-21
owcsimpy: A 3D Simulator for Indoor Optical Wireless Channels	Ardimas Andi Purwita, Tezcan Cogalan, Mohammad Dehghani Soltani, Majid Safari, Harald Haas	NA	Will be submitted
LiFi-based Wireless Edge Caching	Tezcan Cogalan, Ardimas Andi Purwita, Harald Haas	NA	Will be submitted

Moreover, USTRATH's exploitation plan regarding the planned innovations for rest of the project lifetime could also be given as follows:

Table 4-2: USTRATH planned submission

Paper Title	Authors	Type of exploitation
Ultra-Reliable Optical Wireless Communications Through Intelligent Walls	Anil Yesilkaya, Hanaa Abumarshoud, Harald Haas	Book Chapter, "Intelligent Reconfigurable Surfaces (IRS) for Prospective 6G Wireless Networks"
Initial Results for Intelligent eAT3S Oracle	Anil Yesilkaya, Ardimas Andi Purwita, Harald Haas	Conference Paper
Deep Learning Aided Intelligent eAT3S Oracle	Anil Yesilkaya, Ardimas Andi Purwita, Harald Haas	Journal Paper

Further details of the planned innovations are provided in the following sections.

MPTCP Testbed REST-API

This innovation offers a REST-API design and evaluation for testbeds which have MPTCP installed. Specifically, a high-level API that conforms to the REST specification and sits between application and kernel layers is designed, as the existing APIs for MPTCP kernels were very low level and not standardized. This innovation could be used to enable easy access for a reinforcement learning (RL) agent and manage MPTCP-enabled testbeds. Also, by enabling easy access for software developments to create an interactive dashboard to monitor and configure MPTCP-enabled testbeds.

OWCsimPy

This innovation offers a lightweight open-source library that can generate channel impulse responses (CIRs) for LiFi channels within a specific 3D environment. Similar libraries and/or software solutions both in the literature and commercial applications are either closed source or difficult to scale. Thus, we came up with open-source Python libraries based scalable and computationally efficient solution. In addition, the proposed innovation could generate datasets containing many realizations of CIRs of a LiFi channel by considering user that are either walking or stationary. The mobile terminal orientation is also taken into consideration. Furthermore, this innovation could generate path-loss channel models for Wi-Fi and 5G channels for a given 3D geometrical environment as depicted in the following figure. A $4x3x3$ m^3room with a table, chair is depicted in figure, where the user equipment (UE) mobility, terminal random orientation and LiFi AP locations are given by red location vectors.

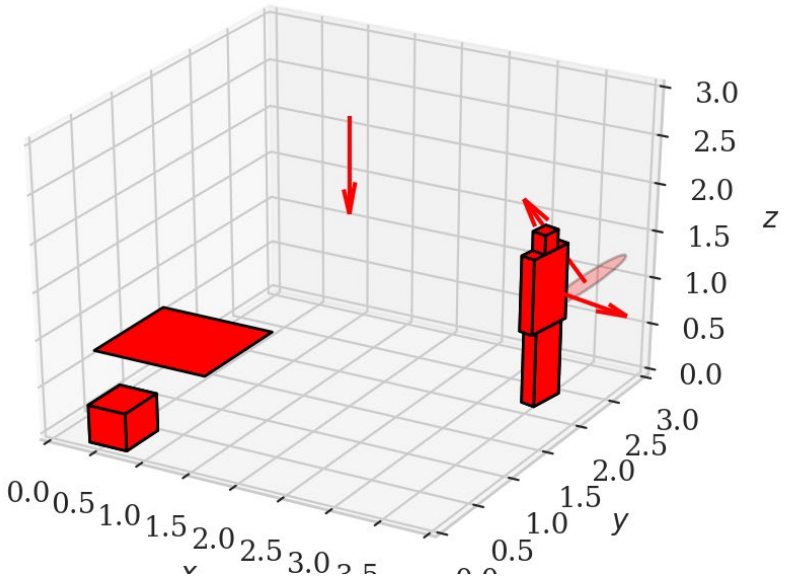


Figure 4-13: Illustration of the OWCsimPy 3D geometrical environment

The OWCsimPy library offers the following features:

- Geometry

  OWCsimPy supports the generation of basic objects, by using Minecraft-like blocks to model basic elements in an environment. Moreover, link blocking detection and object partitioning is also supported by the library.

- Use case

  OWCsimPy has ability to generate the frequency and time domain channel parameterization by Schulze and Carruthers (modified version of Kahn and Barry's). Both approaches are C-optimized and multi-thread enabled.

- User Mobility and Terminal Orientation

  The library is able to model the realistic UE mobility and orientation effects by generating the mobility and orientation patterns by using the values coming from real world measurement/analysis.

In terms of this innovation, USTRATH's exploitation plan is to generate intellectual property (IP), which will be published in high impact conference and journal publications in relevant areas. Further commercialisation of this software package based innovation, potentially by partnerships with large corporates, will also be pursued after a technology transfer process. The whole process is expected to be completed within the time frame of 1 to 3 years from the current stage of the 5G-CLARITY project.

Intelligent eAT3S Oracle

This innovation targets to enhance the performance of the both the user plane (UP) and core network AT3S functionalities presented by 3GPP in release 16. Accordingly, the proposed enhanced AT3S (eAT3S) oracle agent will have the ability to predict and decide the operation mode, switching, splitting, steering, by simply changing the individual wireless access technology (WAT) weights prior and during transmission. The system consists of two main blocks, namely forecasting and decision-making agents, as depicted in the following

diagram Figure 4-14.

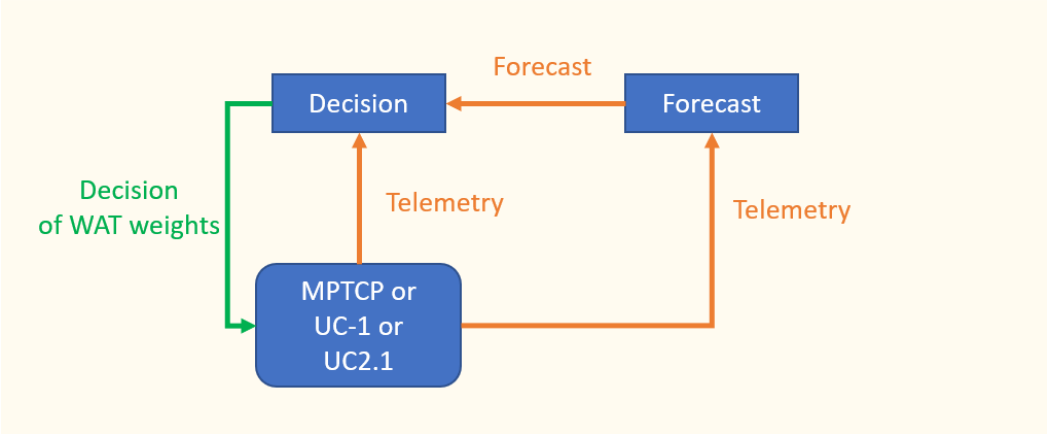


Figure 4-14: Intelligent eAT3S Oracle system diagram.

In a practical network, the telemetry might not always be in abundance, where the periodicity and quality of the data will also be changing over time. However, a fresh and stable feed of telemetry is crucial for decision-making agent to accurately determine the 5GNR, Wi-Fi and LiFi transmission flow weights γ_{5G}, γ_{W} and γ_{L}, respectively. Therefore, the echo state networks (ESN) based forecasting agent is needed to enhance the telemetry quality. Accordingly, the forecasting agent is based on, where the ESNs have computationally simpler architecture compared to long short-term memory (LSTM) technique in capturing complex and non-linear dynamics of the time series data. The following Figure 4-15 depicts the generic ESN architecture, which consists of three main layers: input, reservoir, and output. The main novelty of ESNs comes from the reservoir layer, where the artificial neurons are randomly and sparsely connected to each other. After a quick training period compared to LSTMs, the forecasting agent is expected to be predicting the actual system telemetry for the upcoming time instances with a great accuracy. Note that the actual system could be a simulation environment, a laboratory testbed and/or an actual 5G-CLARITY use case. Thus, by taking the advantage of the forecasted telemetry, the decision-making agent will react to the system level changes in a beyond real time manner. To enhance the forecast accuracy even further, deep ESN could also be utilized.

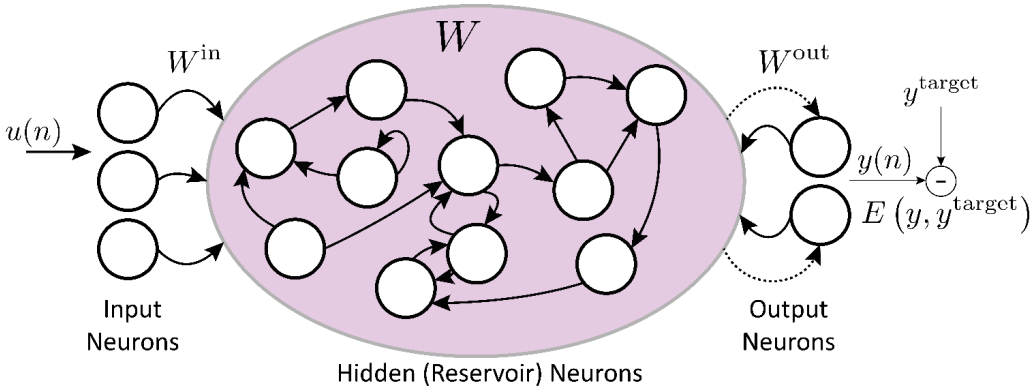


Figure 4-15: the generis ESN architecture.

The decision-making agent in our eAT3S oracle is based on the deep reinforcement learning (DRL) algorithm. Accordingly, the environment that the decision-making agent takes actions on could also be a simulation environment, a laboratory testbed and/or a 5G-CLARITY use case. The optimal policy could be achieved when the system throughput for all the users is maximized.

In terms of this innovation, USTRATH's exploitation plan is to generate intellectual property (IP), which will be published in high impact conference and journal publications in relevant areas. There is no

commercialisation plan regarding this innovation so far. However, this could be an option if progress regarding this innovation exceeds expectations, along with the emergence of significant market growth.

Multi-Policy Scheduler (MPS)

A multi-service light fidelity (LiFi) attocellular network should be resource engineered to efficiently support the fifth generation (5G) services on customized network slices. A cross-layer network multi-policy scheduler (MPS) is developed to support LiFi attocellular networks slicing. A network slice buffer in each LiFi AP attocell is handled by a slice software agent manager. The software agents running in the LiFi APs are characterized by utility functions designed to translate the quality-of-service (QoS) metrics (i.e., delay and throughput) to network resource utility values, as illustrated in Figure 4-16.

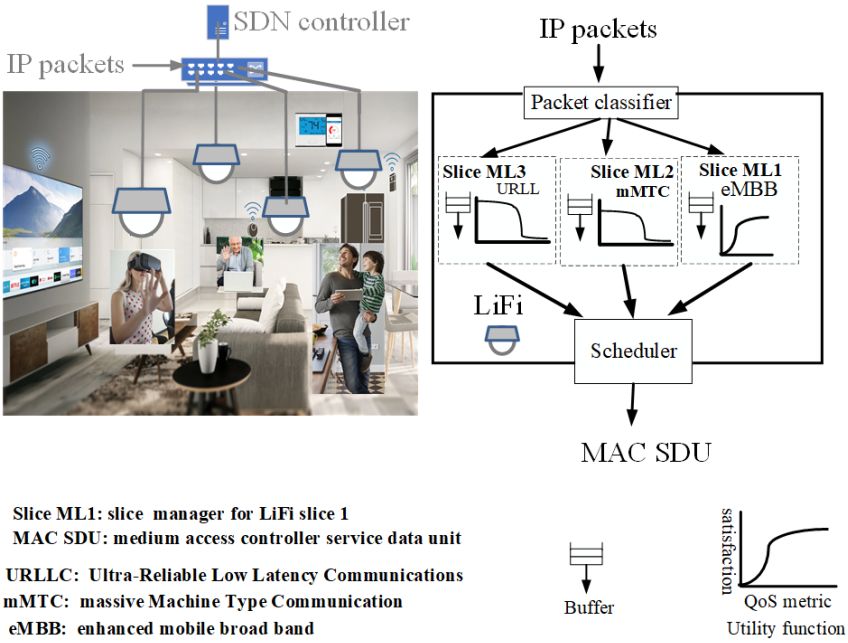


Figure 4-16 SDN-enabled multi-tenant LiFi attocellular network.

The developed MPS mechanism is dictated by two main factors, the utility functions defined for the different slice types, and how the tenants weigh them together by setting a weight to their slice on each attocell *a* in the network, ω_s^a. This slice-specific parameter ω_s^a accounts for the throughput utility weight ω_s^{th} and the delay utility weight ω_s^d, such as $\omega_s^a = \{\omega_s^{\mathrm{th}}, \omega_s^{\mathrm{d}}\}$. The service guarantees of URLLC, mMTC and eMBB are represented in a tuple [u m e] that expresses the percentage of their maximum data rate or resources to be guaranteed during a simulation sub-window time. For example, a service tuple [1 1 1] indicates that the URLLC, mMTC, eMBB services should receive fully their maximum data rate or resource guarantees. Whereas a service tuple [0.1 0.2 0.5] indicates that the URLLC, mMTC, eMBB services should receive a percentage of their data rate or resource guarantees during the simulation sub-window time. These are set by the slice-specific throughput and delay utility weight parameters, which can be programmed by the Software-defined networking (SDN) controller. This paves the way towards programming the sliced LiFi network resource allocation to each MVNO in each attocell in the network according to the availability of mobile network operator (MNP) resources and the business evolution requirements of MVNOs.

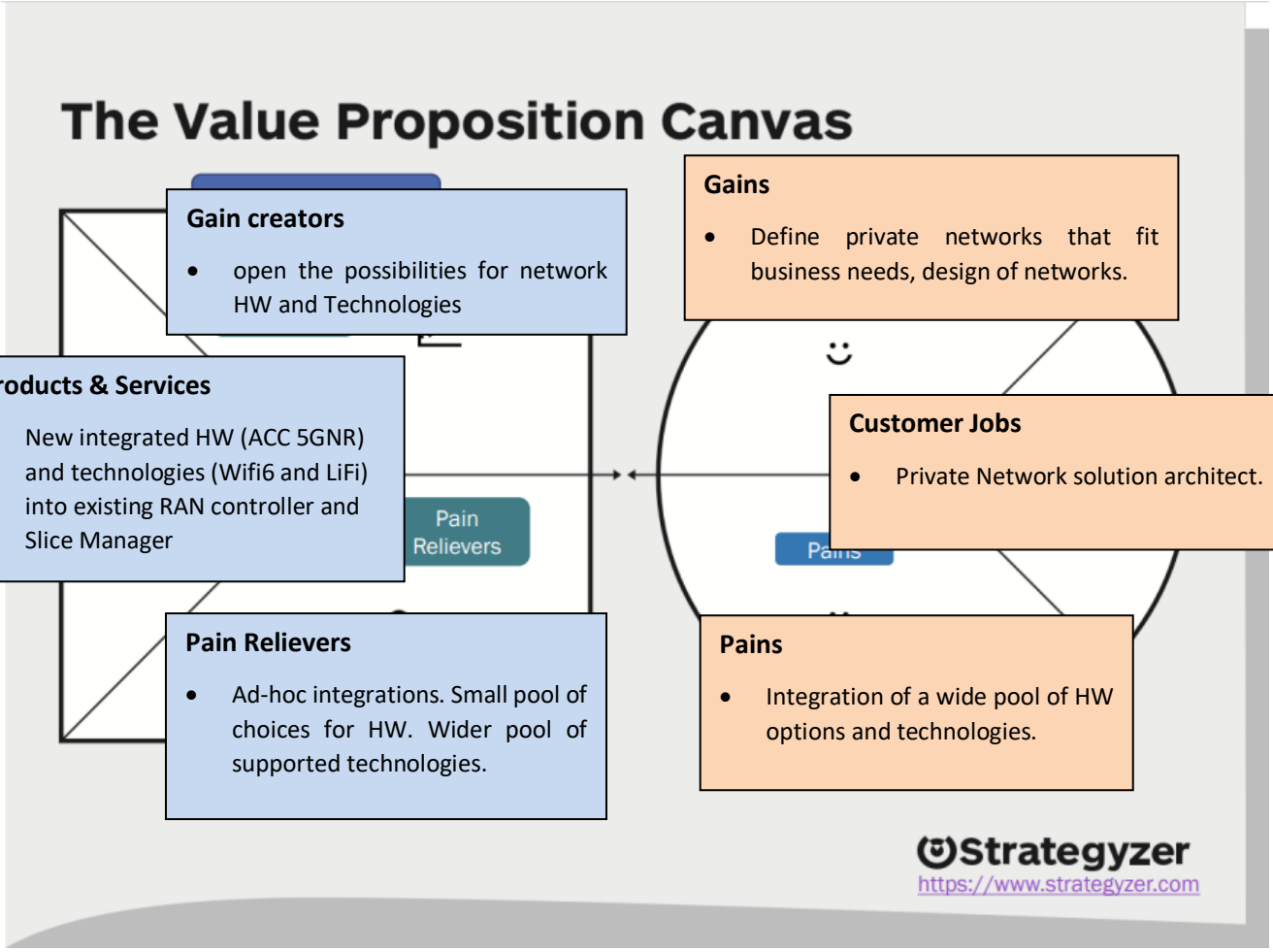
In line with USTRATH's exploitation plan, this research is planned to be published in high impact conference and journal publications.

4.4.3 Fundació I2CAT

In general, i2CAT wants to exploit the results of this project through scientific publications, and through further research projects (e.g. new 5G-PPP projects) and also actively contact the commercial ecosystem to seek licensing agreements.

- **Exploitable Outcome: RAN Controller Improvement (new Features)**
- **Exploitable Outcome: Slice Manager improvements (new Features)**

The value proposition delivered by these two items are analysed by I2CAT and presented in the following VP & Lean Canvases.



<table>
<tr>
<td rowspan="2">PROBLEM
• Limited pool of access technologies and HW options
• Lack of integration with ACC 5gNR
• Lack of support for Lifi
• Lack of support for Wifi6

EXISTING ALTERNATIVES
• Other 5GNR vendors
• WiFi5
• Separate management systems</td>
<td>SOLUTION
• Adapt RC & SM to support Wifi6 and LiFi devices in slices
• Integrate ACC 5gNR and inclusion on Slice compositions.</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION

Improve current i2CAT RAN controller and Slice manager to integrate Lifi, Wifi6 and ACC 5gNR</td>
<td>UNFAIR ADVANTAGE
i2CAT's spin-off Neutroon could be a channel to showcase the asset and the early adopter</td>
<td rowspan="2">CUSTOMER SEGMENTS
• Private network providers with Slice management features.
• Neutroon as licensee of i2CAT Slice manager

EARLY ADOPTERS
• Research Community.
• Neutroon as licensee of i2CAT Slice manager and RAN controller</td>
</tr>
<tr>
<td>KEY METRICS
• Configuration of LiFi/WiFi6 resources: time needed, integration with components.
• Configuration accuracy of NR through SM and RC</td>
<td>CHANNELS
i2CAT Business development areas. i2CAT Tech Transfer Office. Neutroon</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
• Transfer activities
• Development of future services</td>
<td colspan="2">REVENUE STREAMS
• License set-up fee agreement.
• Royalties (per installation, per user, per slice…)
• Future improvements (R&D services)</td>
</tr>
</table>

I2CAT Exploitation Plan for these two items

Slice Manager and RAN Controller are two technologies defined as background from i2CAT. RAN controller and Slice Manager have been improved as part of the work realized on 5G-CLARITY. Both have been improved to include the support of 5GNR gNBs and LiFi Aps control.

As an exploitation strategy i2CAT decided to bundle both technologies, and some more, and has helped create a spin-off named Neutroon Technologies. I2CAT has already licensed the technology to this company and strongly believe in the view of the market as a whole for both technologies and not as separated opportunities, and that is our main exploitation plan path. In particular, we focus on the Private Network market.

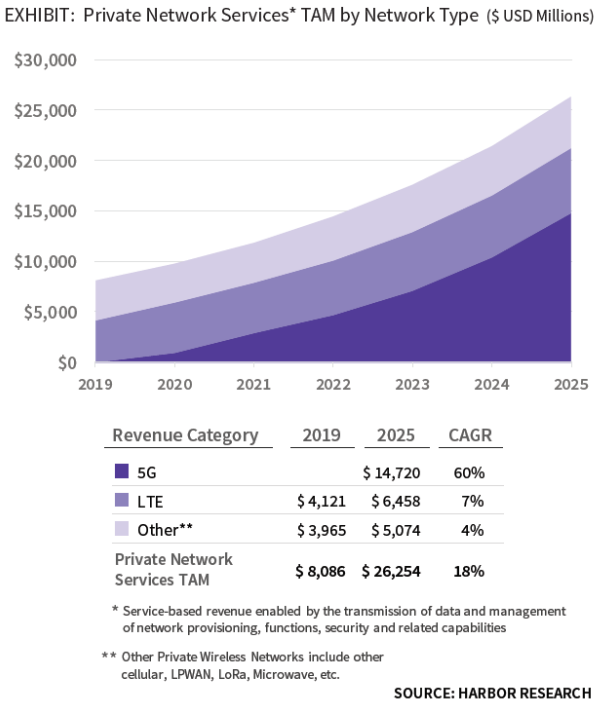


Figure 4-17: Private network growth by network type

According to Market Research Future heterogeneous network market will grow at a CARG of 15% in the 2020-2027 period. They consider that the pandemic, although it has started a global crisis, may present an opportunity for these networks due to the spike in the use of the internet.

Harbor Research foreseen a considerable growth on the market of the private networks in general, and although 5G networks seem to lead the growth, it also considers a CARG of 4% in the 2019-2025 time frame for private networks set up with alternative access technologies.

This increasing demand for private networks opens the space for new players in the ecosystem apart from the current Mobile Networks Operators and the traditional Equipment Vendors, and in this space is where we see an exploitation option for our technologies.

Market research experts like Grad View Reserach differentiates three categories for the private network category growth:

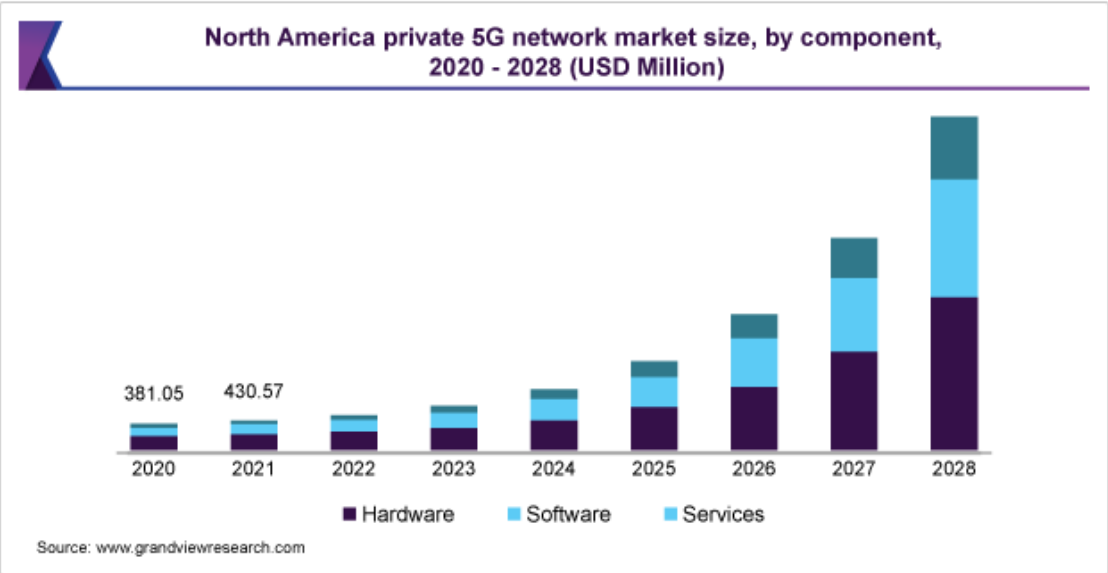


Figure 4-18: Private 5G network market size estimation by component.

The hardware segment mainly encompasses three component categories, including Radio Access Network (RAN), core network, and backhaul and transports. The Software segment demand is expected to ramp up during the forecast period due to the significant focus on deploying cloud-based RAN, core, and edge networks. Increasing challenges faced by the telecom operators for managing their RAN, has raised the need for advanced RAN controllers, RAN orchestration and management platforms.

According to Global Market insights Network Slicing Market alone exceeded USD 200 million in 2019 and is estimated to grow at a CAGR of over 15% from 2020 to 2026. Rising demand for next generation 5G network due to its better bandwidth and speed capabilities will drive the market growth.

Network Slicing Market Report Coverage

Report Coverage	Details
Base Year:	2019
Market Size in 2019:	USD 200 Million
Forecast Period:	2020 to 2026
Forecast Period 2020 to 2026 CAGR:	15%
2026 Value Projection:	USD 600 Million
Historical Data for:	2017 to 2019

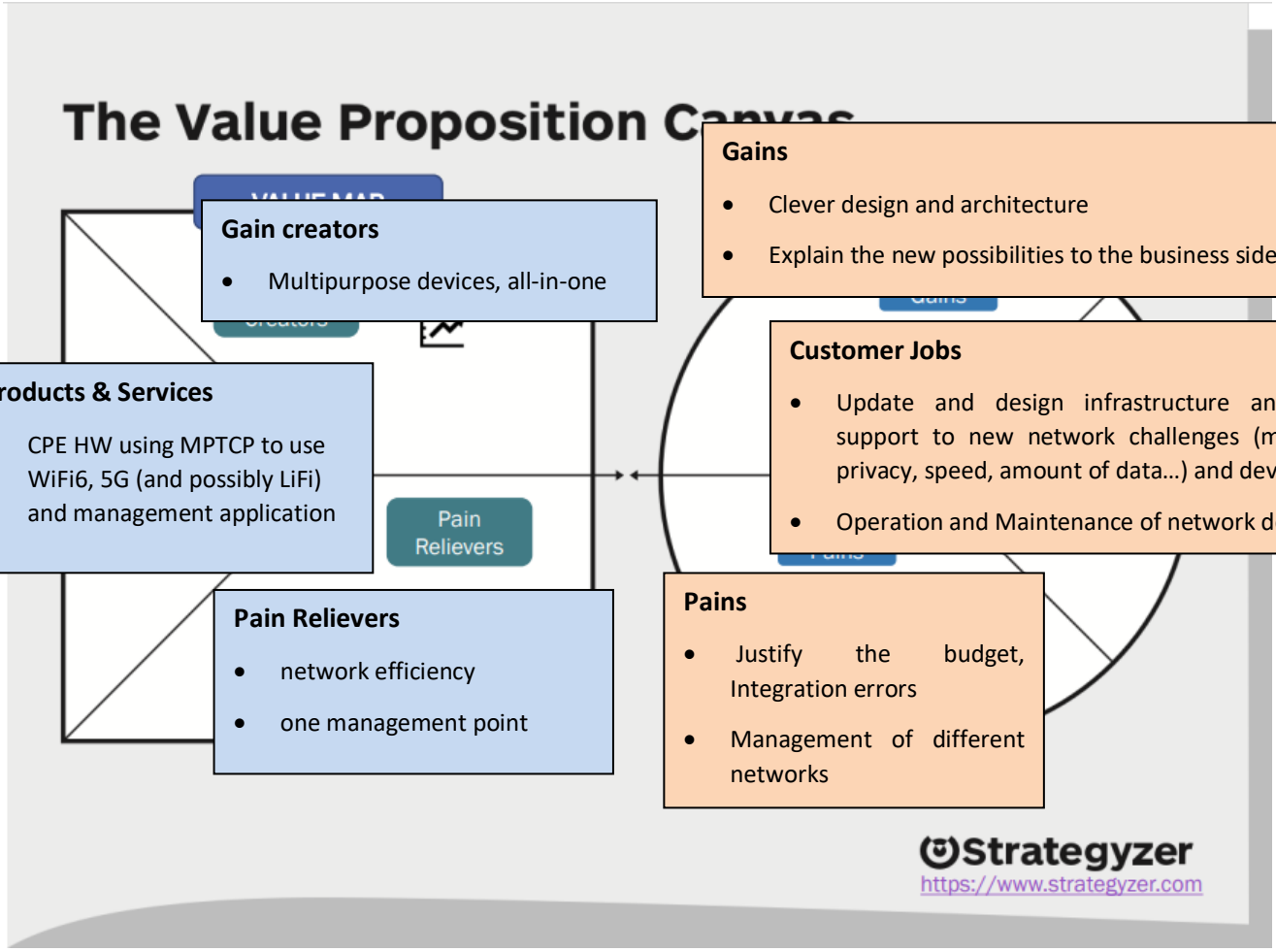
Figure 4-19: Network slicing market report coverage

These trends encourage us to consider that the RAN controller and Network Slicer will be key elements on the management of the private networks, being part of the software and ideally service chunk of the market growth.

All the improvements made inside the project can help our spin-off to win competitive advantage on this ramping-up market.

❖ **Exploitable Outcome: Industrial CPE Wifi6 + 5G (+LiFi)**

The value proposition delivered by this item is analysed by I2CAT and presented in the following VP & Lean Canvases.


The Value Proposition Canvas
Gains
Clever design and architecture
Explain the new possibilities to the business side
Gain creators
Multipurpose devices, all-in-one
Products & Services
CPE HW using MPTCP to use WiFi6, 5G (and possibly LiFi) and management application
Customer Jobs
Update and design infrastructure and give support to new network challenges (mobility, privacy, speed, amount of data…) and devices
Operation and Maintenance of network devices
Pain Relievers
Pain Relievers
network efficiency
one management point
Pains
Justify the budget, Integration errors
Management of different networks
Strategyzer
https://www.strategyzer.com

<table>
<tr>
<td rowspan="2">PROBLEM
• 5G and WiFi downsides -> QoS of each application
• Signal penetration in facilities
• Security control (access privacy…)
• Mixes Neworks with different coverage ranges
• Network bottlenecks
• WiFi latencies
• LiFi AP density needed
• LiFi combination to one room
EXISTING ALTERNATIVES
• Static allocation of services to specific paths in existing 5G + WiFi6 or WIFI+LIFi CPEs.
• Access allocation based on signal strength.
• Single access association per device.
• Single access technology per device.
• Assign 5G access network + complements (added cost)</td>
<td>SOLUTION
• Use of 5G and Wifi6 as if they were the same access.
• Add LiFi as third option. Dynamic path.
• seamless use of WIFI/5G/LiFi</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION
Tech = Scheduler multipath that uses 5G and Wi-Fi based on predefined rules, possible addition of Lifi as 3rd tech.</td>
<td>UNFAIR ADVANTAGE
Patent (To Be Studied), patentability assessment will be done once the results are definitive. i2CAT's spin-off Neutroon could be a channel for implementing private multi access networks and deploy the NFV of the scheduler.</td>
<td rowspan="2">CUSTOMER SEGMENTS
• Industrial equipment (AGV, forklifts...) manufacturers that embed this wireless technology in their operating system.
• Companies that manufacture 5G + Wi-Fi + Lifi connectivity modules CPEs
EARLY ADOPTERS
5G (multi access) private networks in industry.</td>
</tr>
<tr>
<td>KEY METRICS
• Computation load of this function in the OS performance, in CPEs and NFV whitebox.
• Efficiency of available bandwidth (the sum of the three techs), also compared with static options.
• Mission critical packet loss compared to static.</td>
<td>CHANNELS
• i2CAT Business development areas. i2CAT Tech Transfer Office.
• Neutroon recommendations.
• 5G private networks builders as a showcase/ recommendation</td>
</tr>
<tr>
<td colspan="2">COST STRUCTURE
• Transfer activities: commercialization and follow-up
• Researcher hours</td>
<td colspan="3">REVENUE STREAMS
• License agreement.
• Royalties (per installation, per user, per traffic…)
• Future improvements.
• Adaptations to other OS</td>
</tr>
</table>

I2CAT Exploitation Plan for this item

Following the same market trends regarding the private network market referred to in the exploitation plan of the RAN controller and Slice Manager, i2CAT sees that these networks will also imply the need to have connected equipment on customer premises. Our CPE product, with support of WIFI6, 5G and potentially also LiFi will be a step in the direction to cover this need.

We see its potential in the exploitation of the scheduler that controls the multipath over mixed access technologies together with the virtual function controlling the communication on the infrastructure side.

I2CAT has two big customer segments to seek commercialization of this result: Companies that manufacture connectivity modules for CPEs and industrial equipment manufacturers that incorporate wireless access technologies to their products. We will survey the market of CPE providers to see the fit of our solution, showcased in 5G-CLARITY use cases, as a possible adaptation of their operating systems.

Abi Research forecasted a growing demand on the industry for wifi6 CPE, expecting this market to surpass the 263 million units in 2026. According to research and markets the 5G CPE device shipment will reach 498 million units by 2028. These numbers open the possibilities for CPE in heterogeneous networks supporting more than one access technologies and forecasts a growing market where i2CAT results could be exploited.

We want to leverage our competitive advantage, our spin-off Neutroon, as a possible channel to present the private network owners with this solution. We consider that the early adopters of the technology will be related to industrial and manufacturing private networks.

❖ **Exploitable Outcome: OCC positioning system**

I2CAT Exploitation Plan for this item

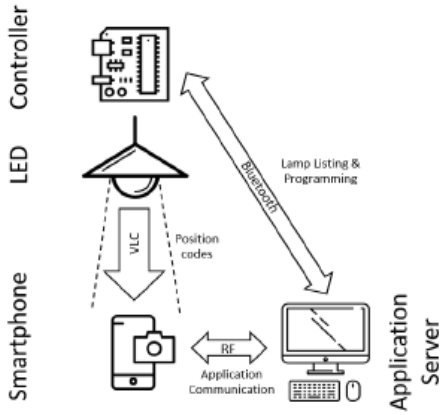


Figure 4-20: Illustration of I2CAT OCC positioning system.

The i2CAT OCC (Optical Camera Communications) Positioning System is an indoor positioning solution based on visible light communications (VLC). A modulated LED light source is used to transmit codes that contain information on the position of the light fixture. By means of a receiver with a CMOS camera or Image Sensor (IS) (smartphone or embedded system) and an application library (SDK) are able to read the position codes and use this information to calculate the 2D & 3D position and the orientation of the receiver. The position accuracy of this VLP system can reach up to 20mm-30mm in 2D, up to 50-80mm in 3D, and up to 3 degrees orientation accuracy.

Key performance information:

- Position updates are configurable and can be as fast as the frame rate of the camera (e.g. 25fps)
- Lower position refresh rate entails lower battery consumption

- Given the above assumptions, we can get a 2D accuracy of around 20mm with a precision of 10mm and an orientation accuracy of 3 degrees.

I2CAT OCC Positioning System solution had already a TRL 6 at the beginning of the 5G-CLARITY project, as it was declared in the background. The solution has been improved to support smaller light sources in the 5G-CLARITY context and it was also an opportunity to showcase the technology in another relevant environment. The prototype was previously demonstrated in relevant environments, showcasing the applicability of accurate 3D positioning using LED lighting for retail, digital signage, and AGV navigation. Specifically, for the AGV industry, we have collaborated with SEAT and performed a pilot for locating an AGV in a warehouse, guiding it through a pre-established route using 12 LED luminaires.

As the first step for the exploitation plan a search of the principal Technologies on the market for guiding the AGV has been carried out. This study helps i2CAT to understand the current state-of-the-art of the market and to compare it with the current benefits of our OCC Positioning System. The main technologies in use currently for the targeted use case are

- Light Detection and Ranging (LiDAR)/Laser Scanner
- Wired guidance
- Tape guidance
- Camera Vision
- Natural Navigation
- Inertial measurement unit (IMU)
- Infrared sensors

Provided the strengths of the solution and the current market niche, we see our Value Proposition into position our technology in three initial markets:

Value for Operators of Large Fleets of AGVs

Generally speaking, it can be assumed that i2CAT's OCC Position Technology will create value for end users who require large fleets of AGV, where a low per vehicle cost (i.e. the sensor cost) and flexible coordination of the AGV fleet and highly accurate docking processes are highly relevant. Under these circumstances investments in infrastructure are relatively less important, especially since the cost for the required LED infrastructure is significant but not prohibitively high.

Value in the Market Segment of AGV with Fix Path Navigation

This market segment will still have a significant market share in the next decade as it is significantly lower cost than laser or visual scanner-based systems. For an AGV manufacturer, it may be worth considering i2CAT's OCC system as a replacement for fix path wire- or tape-guidance technologies in the segment of AGVs with low-cost, low-complexity navigation. The main advantages of i2CAT's OCC system over the existing solutions include higher steering flexibility to change the route of an AGV to different destinations/docking stations, the ability to guide AGVs around obstacles, and the potential for a much more productive and versatile fleet management. In terms of costs, the OCC's sensor cost is similarly low. However, the OCC system needs a more complex and rather expensive infrastructure, a more powerful processor, and more complex software to navigate the AGV.

Value in the Market Segment of Laser Guided Vehicles

Among flexible path indoor positioning systems in AGVs, laser guidance with retroreflector targets currently offers the highest location accuracy available. The theoretical accuracy of laser target navigation is comparable to the OCC's theoretical accuracy. However, the laser-scanners used in laser guided vehicles (LGV) are very costly (we found price quotations for the most widely used SICK S300 laser scanners of $5000-$8000 per unit), so i2CAT's OCC system could create value by offering cheaper sensor technology. This is especially true when a customer requires large fleets of AGVs and infrastructure costs become less relevant in comparison to investment cost per vehicle.

Steps to exploit and optimize the value of i2CAT's OCC positioning system in the AGV market and to push the technology further:

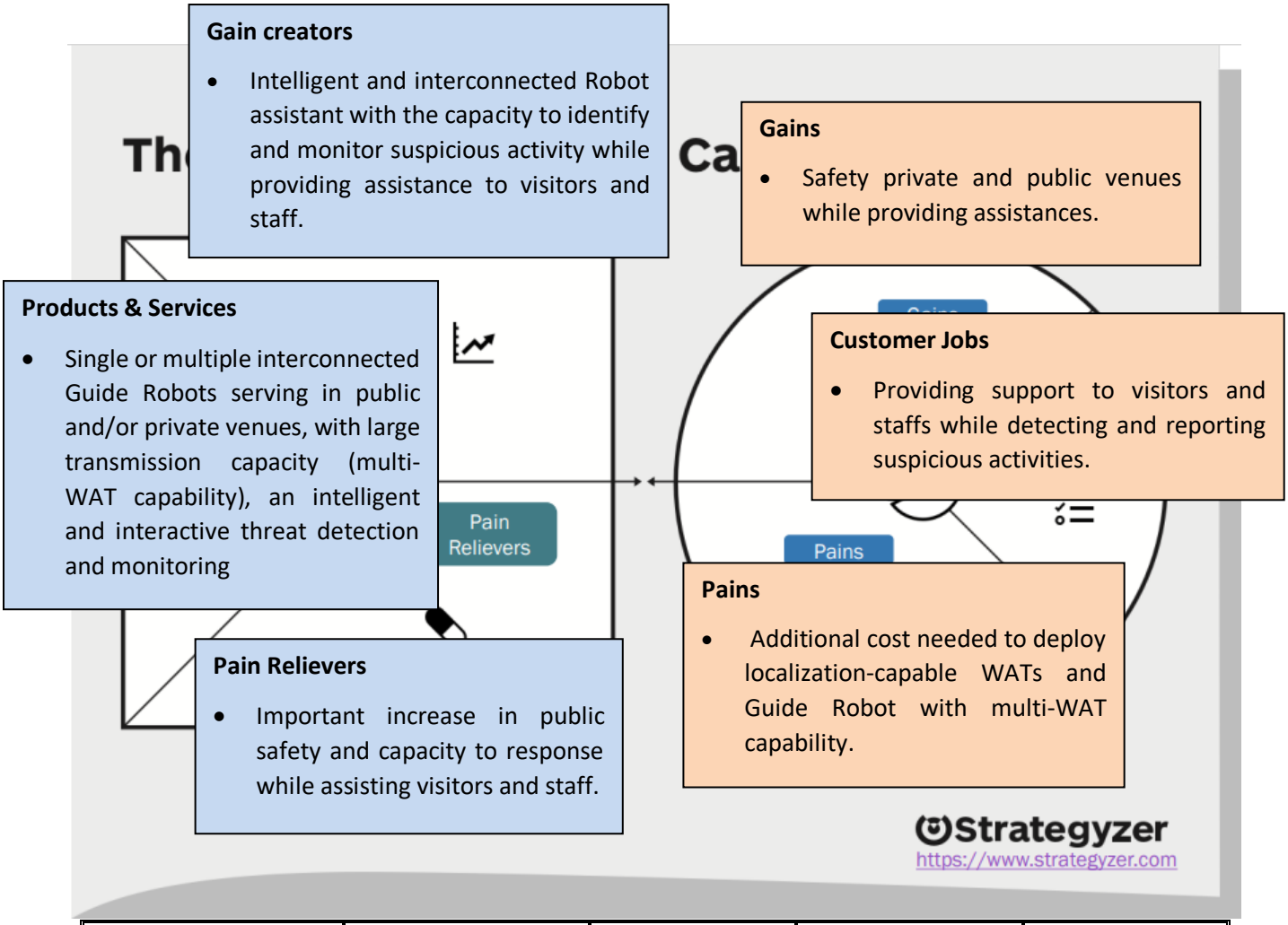
- Target end users with large fleets of AGVs (infrastructure cost less relevant than per unit cost)
- Reduce infrastructure cost by
    - Reducing the number of required LED lights (high resolution camera, fast processor etc.)
    - Providing easy-to-install solutions such as modulators that are integrated in LED lamps, preinstalled rows of LED lamps etc.
    - Creating high and low accuracy zones with high and low LED density respectively
- Find partners that may have business insights to exploit potential for both AGV navigation and smartphone application in warehouse management (large warehouse/logistics companies, material handling systems integrators etc.)
- Target end users with special AGV applications such as in hospitals that may already have a good LED infrastructure in place.

4.4.4 University of Bristol

❖ **Exploitable Outcome: Robotic and AI Assisted B5G Services across Private and Public Networks**

❖ **Exploitable Outcome: Guide Robot for public safety**

The value proposition delivered by these two items is analysed by UNIVBRIS and presented in the following VP & Lean Canvases.



PROBLEM	SOLUTION	UNIQUE VALUE PROPOSITION	UNFAIR ADVANTAGE	CUSTOMER SEGMENTS
• Not existence of public safety enabled Guide Robots in Airports, Malls, and private premises of high affluence of people. • Solutions using	Single or multiple guide Robots equipped with 360-degree camera with multi-WAT connectivity to B5G platform virtualizing and orchestrating AI-based services for advance image processing.	A solution for Intelligent and interconnected Guide Robot Assistance and public safety.	Implementation in existing wireless data communication systems (e.g. Wi-Fi)	public and private venues (e.g., Airports, Malls, Universities, Theme Parks)

<table>
<tr>
<td>infrastructure with cameras are limited.

EXISTING ALTERNATIVES
• Few guide robots' solutions.
• None of them equipped with sliceable and large multi-WAT connectivity and processing for interactive monitoring and threat detection.</td>
<td>KEY METRICS
Automation of the processes that would increase productivity and improve service efficiency.</td>
<td></td>
<td>CHANNELS
• Dissemination
• Business-to-Business (B2B)</td>
<td>EARLY ADOPTERS
• Museums
• Hospitals
• Universities</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
• hardware
• software
• development</td>
<td colspan="2">REVENUE STREAMS
• royalties
• maintenance
• custom service development
• software update</td>
</tr>
</table>

UNIVBRIS Exploitation Plan

The Smart Internet Lab University of Bristol exploitation plan mainly focuses on the deployment integration of prototypes to publish results in high-quality scientific venues (Journals, conferences, magazines). And extend the capability of the 5GUK Test Network to deploy, validate, and demonstrate solutions enabling B5G services and technologies, multi-WAT networks, and AI and Robotic assisted solutions.

Robotic and AI Assisted B5G Services across Multi-domain Private and Public Networks

The UNIVBRIS will focus on validating the solution into the 5GUK Test network in a real scenario to document and publish the first result. Later as Non-Public Networks are on the verge as a commercial solution, we plan to use the validation to approach the appropriate industry verticals to partner ventures or SMEs to develop further the solution validated with grants or seed fundings.

Guide Robot for public safety prototype

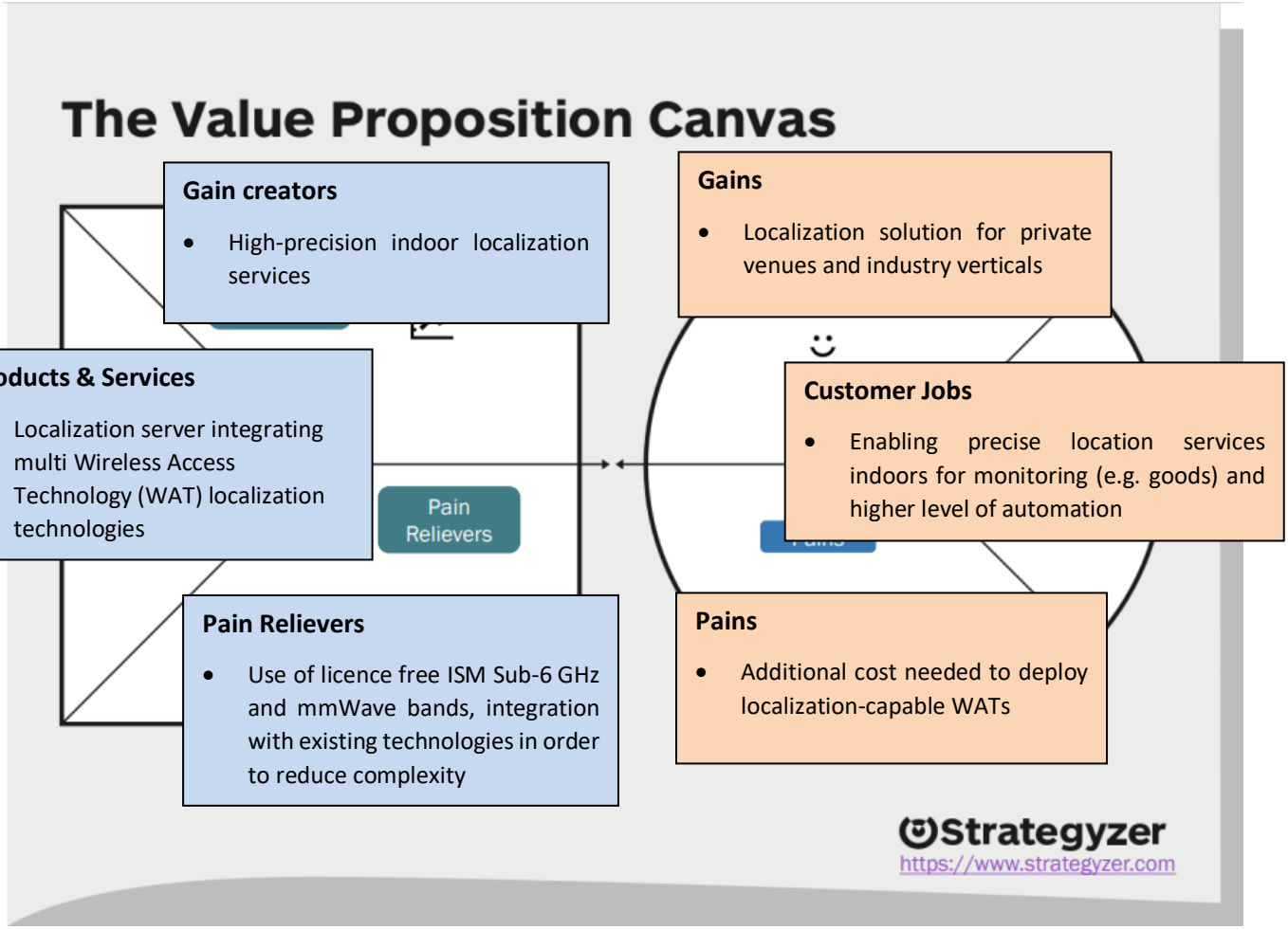
Similarly, to the previous exploitable solution, the UNIVBRIS team plans to produce R&D publications and explore the solution's potential and the industry's interest in the value proposition to continue developing and enhancing through joint projects biddings for grants or partnering SMEs willing to explore the commercial opportunities of the solution. As well as government interest in the solution for public safety.

In conclusion, for both potential products, the UNIVBRIS team aims to exploit as research outcome, demonstration enablers of 5GUK test networks of the University of Bristol and explore the feasibility of moving up on the Technological Readiness Level (TRL) to a pre-MVP.

4.4.5 IHP GmbH

- **Exploitable Outcome: Localization server supporting multiple wireless localization technologies**
- **Exploitable Outcome: Downlink time difference of arrival sub-6 GHz and TWR mmWave localization system**

The value proposition delivered by these two items are analysed by IHP and presented in the following VP & Lean Canvases.


The Value Proposition Canvas
Gain creators
• High-precision indoor localization services
Gains
• Localization solution for private venues and industry verticals
Products & Services
• Localization server integrating multi Wireless Access Technology (WAT) localization technologies
Pain Relievers
Customer Jobs
• Enabling precise location services indoors for monitoring (e.g. goods) and higher level of automation
Pain Relievers
• Use of licence free ISM Sub-6 GHz and mmWave bands, integration with existing technologies in order to reduce complexity
Pains
• Additional cost needed to deploy localization-capable WATs
Strategyzer
https://www.strategyzer.com

<table>
<tr>
<td rowspan="2">PROBLEM
• No universal indoor localization solution
• Available solutions are application-specific only

EXISTING ALTERNATIVES
Proprietary localization solutions used for a single application and not available for universal use</td>
<td>SOLUTION
• Develop localization solutions which can be easily integrated with current wireless data transmission solution
• Develop a localization server that would integrate the current and future localization solutions</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION

A technology independent indoor positioning solution with universal interface towards the user</td>
<td>UNFAIR ADVANTAGE
Implementation in existing wireless data communication systems (e.g. Wi-Fi)</td>
<td rowspan="2">CUSTOMER SEGMENTS
• production
• warehouses
• health

EARLY ADOPTERS
• Smart
• factories
• warehouses
• houses</td>
</tr>
<tr>
<td>KEY METRICS
Increasing the level of automation leading to higher productivity and accuracy.</td>
<td>CHANNELS
• Dissemination
• Business-to-Business (B2B)</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
• hardware
• software
• development</td>
<td colspan="2">REVENUE STREAMS
• royalties
• maintenance
• custom service development</td>
</tr>
</table>

IHP Exploitation Plan for these two items

IHP's exploitation plan is focused towards the dissemination of the obtained results and the proposed approaches and method in scientific publications. This is to make them available to the scientific community, the industry and the policy makers. The primary objective is knowledge transfer acquired during this project.

Within this project IHP is involved in developing localization solutions for RF-based indoor localization, as well as development of a localization server for private networks able to service different wireless access technologies (WATs). During the lifetime of the project several approaches are being developed and valuable results and experiences have been already obtained. These were disseminated in deliverables and papers already published, and the rest of the work will be published towards the end of the project. Additionally, the developed localization solutions will be tested as part of UC 2.2 in a factory owned by the 5G-CLARITY Partner BOSCH for carrying out a precise localization of an AGV that picks up and leaves good along its moving path. This demonstration targets proving the viability and validity of the developed localization solution in an industrial environment.

Sub-6 GHz and mmWave localization

Within this project, IHP is mainly involved in the development and enhancement of a combined Sub-6 GHz and mmWave positioning solution. The details of these systems and the initial evaluation of their performance are given in deliverable D3.2 [6]. Their set up is given in Figure 4-21.

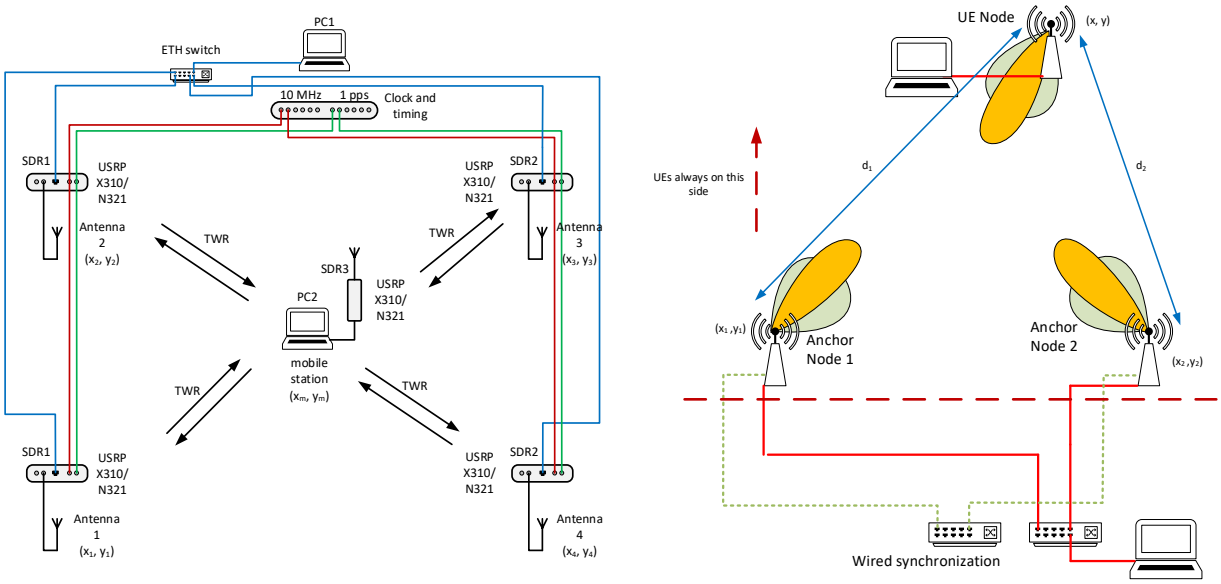


Figure 4-21: Set up of a) Sub-6 positioning solution, b) mmWave positioning solution

The developed positioning solutions are intended for indoor deployment and indoor positioning of a User Equipment (UE) using RF signals. Both solutions are intended to be deployed in the ISM bands at 2.4/5 and 60 GHz. Additionally, these solutions should serve as a proof of concept for indoor localization, which later can be integrated in the future WLAN positioning standards, or used in proprietary positioning systems.

The main goal of these positioning solutions is to bridge the gap that is not covered by the available global navigation satellite systems (GNSS), like for example GPS. These systems are not intended for indoor positioning, given the low GPS signal level in indoor areas. For indoor positioning, the most popular solutions today are the ultra-wide band (UWB)-based positioning systems. The main disadvantage is that UWB does not offer the required data rates demanded by current applications and services, and it is outdated.

Therefore, the positioning solutions based on UWB would only exist as standalone solutions and would hardly be integrated in any future wireless communication solution.

Within this project, we propose alternative solutions that make use of technologies compliant to the current WLAN standards. This means that these solutions can be easily integrated in the future in WLAN positioning standards, or can be used in coexistence with WLAN or other wireless systems working at ISM bands. Additionally, the proposed approach is intended to minimize the usage of the wireless medium and enable high performance positioning for large number of users. This is a main advantage compared to the IEEE 802.11az positioning standard, where the medium usage is proportional to the number of users and positioning requests.

Within this project, we focused mainly on the implementation of these positioning solutions using software defined radios (SDRs) or proprietary hardware developed at IHP, which allow testing the performances of these solutions using real hardware. Moreover, additional improvements and optimizations can be performed in order to achieve high positioning precision and accuracy. The proposed solutions and results have been reported in deliverable D3.2, and the obtained results, after these additional optimizations will be captured in deliverable D3.3. With the developed Proof of Concept (PoC) systems, a positioning precision of ca. 20 centimeters in the 5 GHz band and ranging precision better than 1 centimeter in the 60 GHz band was achieved and demonstrated. This is a valuable output of this project since it demonstrates the achievable positioning precision of the developed system.

These outputs, i.e. the used approach, system architecture and the achieved results are published in deliverable D3.2 and would be additionally published in conference papers.

There are many potential users of these results. Initially, the industry can benefit from these results by using the developed positioning solutions for private indoor usage. Additionally, standardization bodies like IEEE 802.11 can use these results as contributions to the standardization of the next generation WLAN positioning solutions allowing large number of users and optimizing the medium usage. Finally, the research community can extract valuable results from this work in order to perform further research and to additionally improve future positioning solutions. All of these potential users of this technology will be reached via our dissemination strategies or by our participation to different standardization meetings.

Localization server

IHP will develop and integrate a localization server to make use of the positioning capabilities for the different 5G-CLARITY WATs. The details are presented in deliverables D3.1 [5]and D3.2 [6]. The main role of this server is to collect the positioning relevant data from these WATs, and to fuse it offering a reliable and precise positioning information.

A similar approach is already available for LTE, but it does not support different WATs and it is practically unusable for the use cases being investigated in this project. The localization server being developed within this project should overcome this gap and allow multiple WATs to be used simultaneously. It is intended to be deployed in private networks, making the positioning data available only to the users in this private network.

Within this project, the main focus would be on the concepts for the localization server as well as the functionalities being implemented into it. The main goal would be to describe how positioning data would be exchanged between the localization server, the WATs and the users requiring positioning data. Additionally, IHP proposed a data fusion approach that was implemented and tested in simulation.

The proposed approaches and the obtained results are currently being reported in the deliverables as well as in conference papers. The remaining work in the localization front will be disseminated in in a similar

manner.

The potential users of the proposed approaches and the obtained results will mainly be the industry and the standardization bodies as well as the research community. The industry and the standardization bodies can use the outcomes of this work for further developments/upgrades of similar concepts, which can be additionally standardized by the SDOs. The research community can also use these results as a basis for further improvement and research. Both types of target audiences will be reached through dissemination activities, workshops, and by the attendance to IEEE standardization meetings.

5 Use Case Analysis

5.1 UC1: Enabling Enhanced Human-Robot Interaction (Smart Tourism)

5.1.1 UC1 Scope and Objectives

As reported in 5G-CLARITY D5.1 [7], the main goal of 5G-CLARITY UC1 is to validate and demonstrate the benefits of the 5G-CLARITY multi-WAT and NPN enabled framework and infrastructure in a public museum environment to enhance the interactions between a guide robot and visitors. This can be formulated in the following objectives:

- To integrate, validate, and demonstrate a smart tourism application in a museum supported by the 5G-CLARITY architecture for intelligent, flexible, and robust interactions between visitors and a robot as tour guide (Standalone NPN (SNPN) scenario described in 5G-CLARITY D2.2 [22]).
- To validate and demonstrate the 5G-CLARITY framework to support elastic and robust NPN extensions through E2E slicing for on-demand services such as secure connectivity for emergency and public safety surveillance systems and third-party special events (Public Network Integrated NPN (PNI-NPN) scenario described in 5G-CLARITY D2.2 [22]).

More details on UC1 can be found in 5G-CLARITY D5.1 [7].

5.1.2 UC1 Lean Canvas Analysis

- Problems:
  - Very limited assistance and emergency support in public and private venues with high affluence of visitors or humans.
  - Very few solutions to increase the opportunities for new revenue streams through infrastructure sharing for non-public network adopters and new services.
  - Deploy more humans as staff for threat detection and emergency support expose several challenges with the coordination and safety of the staffs.
- Existing Alternatives:
  - Some solutions based on Guide Robots are deployed in very small number of Airports and Malls with limited connectivity and capacity.
  - Human based public safety and emergency systems exist in most location.
- Solution:
  - A group of interconnected guide robots supported by B5G communication for visitors' assistance, threat detection, and emergency support will minimize the response time and life-threatening situations.
  - A solution allowing non-public network owners (private and public venues) to add third party services might increase the revenue opportunities and popularity of their venues.
  - Using one or a group of guide robots to interact emergency will reduce the exposure of humans to many dangerous threats and reduce the response time during a catastrophe.
- Key Metrics:

  - Large number or percentage of visitors satisfy with the services.
  - Large number or percentage of visitors and staff feeling protected.
  - Capacity to have multiple services running in the same infrastructure.

- Unique Value Proposition:

  Smart and Efficient Guide Robot solution supported by a multi-WAT network and AI Engine to provide efficient assistance, public safety, and emergency response to visitors and staffs, while allowing third party services for revenue opportunities for NPN owners.

- Unfair Advantage:
  - The Guide Robots technology
  - Wireless technology
- Channels:
  - Business-to-business (e.g., University offering support to museum or airport)
  - Government
- Customer Segment:
  - Malls or shopping centres.
  - Museum or historical venues.
  - Airports and train stations
  - Hotels and venues for large public events.
  - Universities and colleges.
  - Public locations with large affluence of visitors.
- Early Adopters:
  - Museum
  - Train stations
- Cost Structure:
  - Cost of the Guide Robot solution
  - Multi-WAT and Local Area Network for Non-Public Network (Might be existent)
  - Hardware (Edge Cluster)
  - Software
- Revenue Streams:
  - Third party services
  - Advertising
  - Royalties

5.2 UC2.1: Alternative Network to Exchange Production Data (Industry 4.0)

5.2.1 UC2.1 Scope and Objectives

As reported in 5G-CLARITY D5.1 [7], 5G-CLARITY UC2.1, 'Alternative Network to Exchange Production Data', is aimed to demonstrate 5G-CLARITY key innovations in improving the in-factory connectivity toward future Industry 4.0 scenario networks. 5G-CLARITY UC2.1 will be implemented in RBEF (Robert Bosch España Fábrica Aranjuez), a Bosch factory located in Aranjuez near Madrid, Spain. The main objective is to validate the feasibility of replacing current Ethernet wired connections used to connect Manufacturing Execution System (MES) enabled production lines in the factory floor by the combination of wireless technologies proposed in 5G-CLARITY.

By deploying the 5G-CLARITY infrastructure and solutions in the UC2.1 scenario, an improvement in data transmission speed is expected while reliability, latency, data security and response time are maintained. The benchmark will be the currently in-place wired network performance. If the 5G-CLARITY solution based on the considered WATs can meet the performance benchmark, it will prove that wireless solutions can replace current wired connections.

More details on UC2.1 can be found in 5G-CLARITY D5.1[7].

5.2.2 UC2.1 Lean Canvas Analysis

- Problem:
    - Communicate machines among them and with the factory servers
    - Lines and machines are difficult to move/reconfigure
    - Existing wireless connections show signs of saturation

- Existing Alternatives:
    - Ethernet network with 1 cable per machine to a Head-of-Line (HoL) switch + monomode optic fibre from HoL switch to factory servers
    - Every time a machine has to be moved, a new cable is installed
    - Factory services are assigned priorities according to their importance
- Solution:
    - Wireless 5G connection from machines to HoL server
    - Wireless connection allows easy reconfiguration of machines
    - 5G and next-generation WiFi provide increased bandwidth
- Key Metrics: Productivity, Quality level, cost reduction
- Unique Value Proposition: The Bosch Group is the fifth global patent holder, and the highest-ranked European company in the list. The pursuit of the highest standards of quality and customer satisfaction by constant innovation and cutting-edge technology has been constant since the company was founded more than 130 years ago. The company founder, Mr. Robert Bosch, stated this quite clearly. In his own words:

"It has always been an unbearable thought to me that someone could inspect one of my products and find it inferior in any way. For that reason, I have constantly tried to deliver only products which withstand the closest scrutiny – products which prove themselves superior in every respect.

"We should all strive to improve on the status quo: none of us should ever be satisfied with what has been achieved but should always endeavour to do better."

This is the Bosch way

- Unfair Advantage: The Bosch Group is not in the stock market. This allows the company to pursuit long-term goal without the worry of quarterly financial reports.
- Channels: /
- Customer Segment: /
- Early Adopters: /
- Cost Structure: This information is subjected to Data Protection and cannot be disclosed
- Revenue Streams: This information is subjected to Data Protection and cannot be disclosed

5.3 UC2.2: Enhanced AGV Positioning for Intralogistics (Industry 4.0)

5.3.1 UC2.2 Scope and Objectives

As reported in 5G-CLARITY D5.1 [7], 5G-CLARITY UC2.2 aims at enhancing the positioning of an AGV in the shop floor of a Bosch factory described in 5G-CLARITY D2.1[8]. 5G-CLARITY UC2.2 will include an AGV operating on a shuttle service between a warehouse and a production shop floor, in RBEF, Bosch factory located in Aranjuez near Madrid, Spain. Since the two ends of the AGV route are located in different buildings, part of the route will be outdoors. However, only the indoor part of the AGV travelling route is within the scope of the 5G-CLARITY UC2.2.

To obtain the accurate position of an AGV in real time, a multi-technology positioning system will be implemented that is able to retrieve real time information about the position of the AGV within the premises. The main aim of 5G-CLARITY UC2.2 is to achieve real time positioning of the AGV with cm precision and retrieval of the disturbances on the AGV route.

More concretely, 5G-CLARITY UC2.2 expected output is the collection of AGV positioning data in real time with enhanced accuracy using 5G-CLARITY multi-WATs. Accurate positioning information allows recording, evaluating and management of incidents on the factory shop floor along the AGV routes. The details of these incidents, e.g., precise location, exact time, etc., will be recorded and the corresponding data base can be used to improve the productivity.

More details on 5G-CLARITY UC2.2 can be found in 5G-CLARITY D5.1 [7].

5.3.2 UC2.2 Lean Canvas Analysis

- Problem:
    - Monitor position of AGV to ensure that there is no collision against machines
    - Extra space must be allocated to the AGV to ensure no lateral collision against persons or machines
    - Reasons for delays in the AGV route are not known.

- Existing Alternatives:
    - AGV is positioned by reference to Wi-Fi antennae with known positions
    - Widened aisles to ensure a safety distance during the AGV course
    - Unexpected GV stops must be noticed manually
- Solution:
    - A combined solution with 5G, WiFi and LiFi provide increased positioning accuracy
    - Increased positioning accuracy allows aisles to be narrower, thus gaining more surface for production machines and increasing overall productivity
    - Image acquisition and processing coupled with high-accuracy AGV real-time positioning allows determination of the causes for emergency AGV stops and braking. Later data analysis will allow identification of problem zones and times, and subsequent delay reduction
- Key Metrics: Productivity, Quality level, cost reduction
- Unique Value Proposition:
- The Bosch Group is the fifth global patent holder, and the highest-ranked European company in the list. The pursuit of the highest standards of quality and customer satisfaction by constant innovation and cutting-edge technology has been constant since the company was founded more than 130 years ago. The company founder, Mr. Robert Bosch, stated this quite clearly. In his own words:

  “It has always been an unbearable thought to me that someone could inspect one of my products and find it inferior in any way. For that reason, I have constantly tried to deliver only products which withstand the closest scrutiny – products which prove themselves superior in every respect.

  “We should all strive to improve on the status quo: none of us should ever be satisfied with what has been achieved but should always endeavour to do better.”

  This is the Bosch way
- Unfair Advantage: The Bosch Group is not in the stock market. This allows the company to pursuit long-term goal without the worry of quarterly financial reports
- Channels: /
- Customer Segment: /
- Early Adopters: /
- Cost Structure: This information is subjected to Data Protection and cannot be disclosed
- Revenue Streams: This information is subjected to Data Protection and cannot be disclosed

6 Conclusions

As an additional restricted deliverable, this document is prepared to address reviewers' comments received during the interim project review meeting in July 2021. It describes the exploitable outcomes from the 5G-CLARITY project and reports on the updated exploitation plan.

In particular, this deliverable firstly introduces the several categories of exploitation outcomes. As the 5G-CLARITY consortium includes partners from academic to industrial sectors, the diversity of expertise and prospects are reflected to their exploitation strategy and activities. To analyse and address the exploitation plans more properly, the exploitable outcomes are identified as three types: "Prototypes/products", "Research Achievement" and "Demonstrators". The definitions are given in the deliverable and the methodologies for analysing them are also introduced accordingly.

With the given categories and methodologies, the 5G-CLARITY exploitable outcomes are summarised in Table 3-1, and briefly introduced in the following section. The list includes all the individual outcomes from each partner and also the three use case demonstrators which contain cooperation from multiple partners.

In the next part of the deliverable, the methodology analysis and exploitation plan for all these exploitable outcomes are given in details. The original exploitation plan has been proposed in 5G-CLARITY D6.1[1] and they have been reported here with modification and updates as the project goes further. In addition, the Lean canvas analysis has been presented for the several use case demonstrators.

This deliverable is positioned as an additional interim material reporting on the exploitation plans within 5G-CLARITY project. More complete analysis on the exploitable outcomes together with regular updated exploitation plans will be reported in '5G-CLARITY D6.5 – Final report on innovation management, exploitation and IPR'.

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