GAIA - Green Awareness In Action

D5.5 – Sustainability Plan & Innovation Roadmap

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Abbreviations

Abbreviation	Expression
API	Application Programming Interface
BACS	Building Automation and Control Systems
BMA	Building Manager Application
DoW	Description of Work
EC	European Commission
EPB	Ethics and Privacy Board
GA	General Assembly
IPR	Intellectual Properties Rights
PhC	Phone Conference
PM	Person Months
SC	Steering Committee
SWOT	Strengths, Weaknesses, Opportunities and Threats
TC	Technical Committee
TCB	Trials Coordination Board
WP	Work Package

Executive Summary

GAIA project has been innovative in the approach it followed to shape the students' behaviour (societal innovation), the strategies it has followed to achieve energy savings (environmental impact) and in the way it targets exploitation of technological/scientific results through open source components.

In this document, we define the innovative outcomes of the GAIA project and we present the plans for managing innovation and ensuring sustainable exploitation of the results. The plans are organized in short and longer term and are based on thorough market surveys as well as on studies of the political trends and of the identified opportunities. The competition for the technological (mainly) outcomes is also analysed.

GAIA partners feel it is important to note at this point that the results of the GAIA pilot have strengthened their positive feelings for the targeted market and thus their commitment to exploit the produced results. Even though the exploitable results are of quite different natures (from pedagogical scenarios and educational material to dockerised IoT platform), all GAIA partners have realized that the GAIA application set is a unique quiver of arrows to achieve the utmost goal of energy efficient behaviour.

Contents

1. Introduction

This deliverable is the outcome of task 5.3 addressing the "Business Uptake & Innovation Management". This task has been monitoring the evolution of the technology, the market and the relevant opportunities in order to define concrete plans for sustainability of the results and exploitation of the generated innovation, post project. In parallel to this monitoring, the user-centered approach embraced by GAIA has led to the delivery of a first, really close to market, solution that has undergone initial validation across EU. The aim is to: a) make use of the results, recognizing exploitable results and their stakeholders and b) concretize the value and impact of the R&I activity, for societal challenges.

In GAIA, we define sustained availability not only as means to prevent decay of capabilities over time while keeping the overall level of support unchanged, but also to enable and empower GAIA to continuously reinvent and renew itself in line with the newest technological developments and trends and thus, extend its potential. We have made public the GAIA platform, hence encouraging interested schools and educational institutes, as well as companies (including SMEs) to pick up and continue this work. The project success will also point to the need for similar initiatives for other elements. These activities include maintenance of (and upgrades to) the software solutions and will ensure, for instance, regularly updated GAIA software versions, continuous knowledge capturing and management. This will enable GAIA to be established as one of the leading references for innovative energy efficiency tools in school buildings and educational community.

In this deliverable, we first define the key exploitable results of GAIA (in Chapter 2) which are of diverse types (from software to pedagogical scenarios). Since a major of GAIA's results are delivered as open source and are publicly available, we define in Chapter 3 the ways that the GAIA partners intend to follow towards commercially exploiting these results, ensuring their sustainability and availability. In Chapter 4, we provide the market insights based on which detailed exploitation activities are defined. In Chapter 5, the GAIA innovation roadmap is presented. This is the white paper roadmap that the project will widely publish once the project's activities have been completed taking also into account the content of deliverable D4.3. Then, in chapter 6, individual exploitation plans (to the extent that these can be disclosed) are provided.

2.   GAIA Key Exploitable Results

The key exploitable results generated by the GAIA project are shown in Figure 1, which produce a corresponding impact in society, the environment and the economy. All GAIA results and impacts are in line with the mandates of Horizon 2020 targets and mainly focus on the society and the environment rather than on the technology and the science.
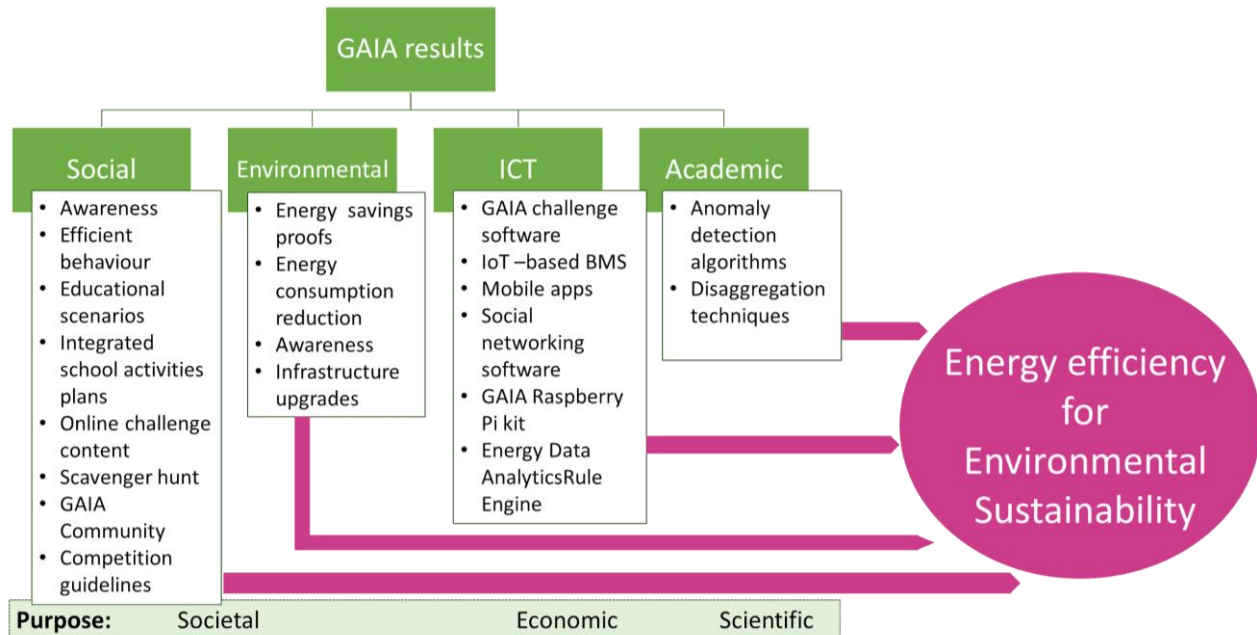

Figure 1 The key exploitable results of the GAIA project

GAIA results can be categorized as follows:

- **Social impacts:** GAIA has very important impact on the level of
  - energy efficiency awareness and consciousness as will be elaborated in deliverable of WP4 (where pilot results are reported).
  - Feeling of (common) responsibility: the engagement of the end-user and more specifically of the students (also to be reported in deliverables of WP4) is reflecting the users' feeling of responsibility with respect to energy efficiency and sustainability.

To ensure the engagement of additional people and the sustainability of the GAIA project's results, GAIA has produced and delivers publicly a large set of educational scenarios for schools in Greece and in Italy as well as for technical high schools in Sweden. These educational scenarios include: course teaching plans and materials, plans integrating school teaching, interaction with the GAIA challenge and validation of results through the BMA, content for the GAIA challenge (which is focusing on the energy efficiency aspects selected by the project), the community gathered around the GAIA project which covers 28 schools in 3 countries and finally, guidelines for organizing competitions within and among schools, within and among countries.

- **Environmental impacts:** GAIA has achieved significant improvement of energy efficiency in the schools where the GAIA approach was piloted. These achievements stem:
  - Energy efficient behavior.
  - Changes in the infrastructure (e.g. replacement with LED bulbs).

The impact of these interventions was measured using the GAIA ICT tools. These tangible results will act as the lighthouse that will drive additional activities in the schools where GAIA was piloted as well as in additional schools that can run similar activities post GAIA project. (GAIA partners are already exploring was to replicate their campaigns in additional schools).

- **ICT solutions** which are technology-oriented and include the GAIA Challenge software, the IoT-based Building Manager Application, the GAIA mobile apps (an Android app[1] which provides access to the BMA platform, as well as a mobile app supporting the reading of the sensors of the mobile device and their upload to the GAIA BMA), the social networking app software, the Raspberry Pi kit, as well as individual components like data analytics and the composite rule engine components. The majority of GAIA's software code can be found in https://github.com/GAIA-project. The **main selling point** of these solutions is that they are tailored to school buildings and communities' needs and that they are flexible in accommodating sensors from various vendors.
- Regarding research outcomes of the project, they include anomaly detection algorithms and disaggregation techniques developed by OVER, a rule-based recommendation engine developed by CNIT, as well as an integrated large-scale IoT data processing platform developed by SPARK and CTI. CTI has also produced an extensive set of results regarding the application of the GAIA approach in an educational and sustainable context.

Each of these outcomes offers a unique value proposition to its targeted users and different exploitation pathways are better suited for each of them. For this purpose, GAIA has decided to embrace both lean methodology and legacy business plan development tools to define their exploitation strategy. These include tools such as the PEST and SWOT analyses.

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[1] GAIA Companion, https://play.google.com/store/apps/details?id=eu.gaiaproject.android.companion

3. GAIA Open Source results exploitation pathways

GAIA has decided already from the proposal-writing phase to deliver its results in an open source manner. This decision has been confirmed during the project's lifetime. Although making the majority of the project's outcomes publicly available seems to contradict commercial exploitation, this is not necessarily true; a set of pathways exist that can be followed by the GAIA consortium, or third parties, in order to create revenues from such results. Furthermore, commercial exploitation is by no means preventing the sustainability of the GAIA results as will be shown further down in this document, in which we describe different ways for commercial exploitation of GAIA results (either from GAIA partners or third parties) and provide examples.

3.1 Support Contracts

Any sophisticated open source application, like the BMA, is free to download but needs to be installed in hardware of specific requirements and thus, even though elaborate documentation and guidelines are provided, it requires relevant expertise for customization and support. For example, for the current BMA version to remain available, the maintenance of the relevant server over time requires effort. Furthermore, to extend the current content to cover additional energy efficiency habits, design and development is needed. This can be done by any IT-company possessing the relevant expertise. GAIA partners that produced these solutions have the advantage of achieving this at lower cost, as they already possess such expertise.

Another example lies with the BMA, where schools may decide to increase the number of IoT sensors in the building, in which case they will need assistance in installing the hardware and connecting it with the platform. For individual components like the anomaly detection, its integration may require deep knowledge of the relevant APIs and functionalities. For a third party to use it, it may be more convenient and cheaper to set up a contract with the relevant GAIA partner to integrate it with other existing solutions. The rates may vary for different levels of support, which can range from immediate phone to slower email-based support.

3.2 Sell Value-Added Enhancements

Although the basic GAIA open source solution may be free, organisations may create and sell add-ons that provide additional value. For example, the open source educational scenarios can be augmented and/or tailored to other levels of education or other countries. GAIA partners that were involved in the design of the educational scenarios have a clear advantage in designing and delivering enhanced versions tailored to other target groups, since they already have experience and know how the children and their teachers interact with the materials.

Another example could be the enhancement of the Building Manager Application to fit the needs of other buildings like elder people residences, hospitals or office buildings.

3.3 Sell Expertise as a Consultant

GAIA partners have developed a set of IT tools and a set of educational scenarios/plans. Replicating these scenarios to cover additional schools requires expertise and no one else is better suited than the GAIA partners are. Already at the time of writing this document, GAIA partners have been contacted by other companies (energy providers) who are interested in replicating the success story of the GAIA pilots in additional schools in the framework of their Corporate Social Responsibility activities.

4.   Market Analysis

The GAIA results target the market of energy management systems (EMS), as well as the Education market – the segment of educational methods and materials in specific.

4.1 Current Status of EMS market

Energy consumed in the buildings' sector, residential and commercial, accounts for 20.1% of the total delivered energy consumed worldwide [1]. Buildings in the EU are responsible for 40% of primary energy consumption, of which 85 % is used for room heating and room cooling, as well as 15 % for electrical energy (in particular, for lighting).

While new buildings generally need less than 3 to 5 liters of heating oil per square meter per year, older buildings consume about 25 liters on average; some buildings even require up to 60 liters. Currently, about 35% of the EU's buildings are over 50 years old. By improving the energy efficiency of buildings, we could reduce total EU energy consumption by 5% to 6% and lower CO_2 emissions by about 5%, [2], [3]. In Figure 2 the buildings energy use per sector is presented.
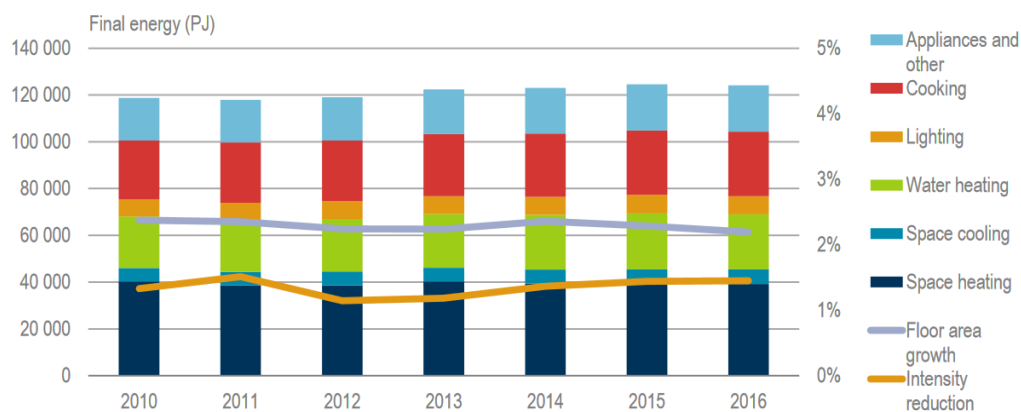
Figure 2 Buildings sector energy consumption, energy intensity and floor area (2010-16), IEA 2017, [4]

Focusing our market analysis in the **Educational** and Residential sectors, we find that **educational buildings constitute 17% of the non-residential building stock in the EU**, [5]. Energy expenses in schools have been treated as relatively fixed and inevitable. Evidence shows that a focus on energy use in schools yields an array of important rewards in concert with educational excellence and a healthful learning environment [6].

Figure 3 Final energy consumption in the residential sector by fuel, EU-28, 2016 [7]
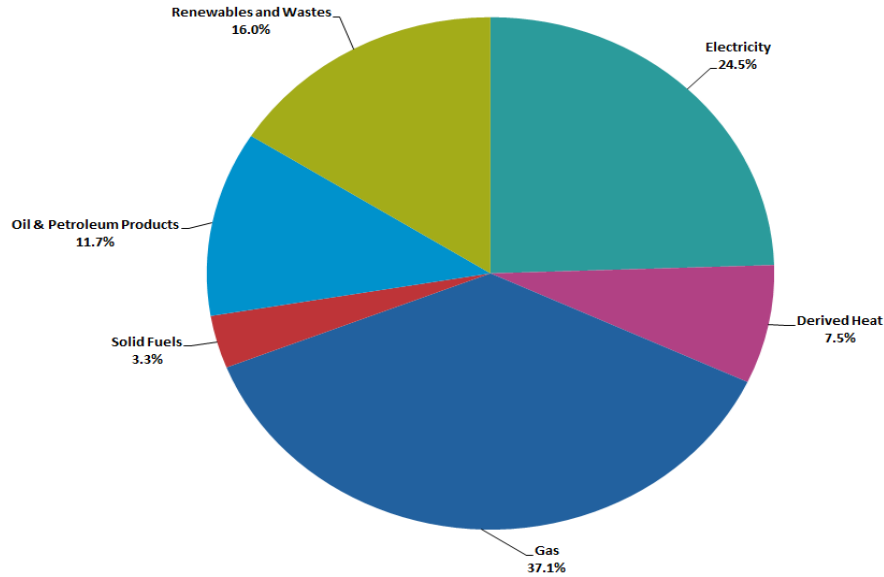
As EIA states, energy consumption in the residential sector includes all energy consumed by households, excluding transportation uses. It includes energy used for heating, cooling, lighting, water heating, and consumer products. In Figure 3, the energy use in the residential sector by fuel is depicted. Natural gas is the dominant source of energy for households in the EU. Electricity ranks second representing 25.4% of total final energy consumption for Europe in 2016, [7] and its share is increasing rapidly. Oil is slowly being phased out at EU average but remains significant in island countries [8].

Taxes and levies explain high prices in some European countries. The energy pricing trends for the EU are depicted in Figure 4. Air Conditioning represents 10% of total electricity consumption in the largest AC consumers, while the average consumption per dwelling for this end-use is increasing as the AC stock is increasing. In most homes, 44% of utility bills goes for heating and cooling while 10% of domestic electricity is consumed for lightning in the EU, [9].
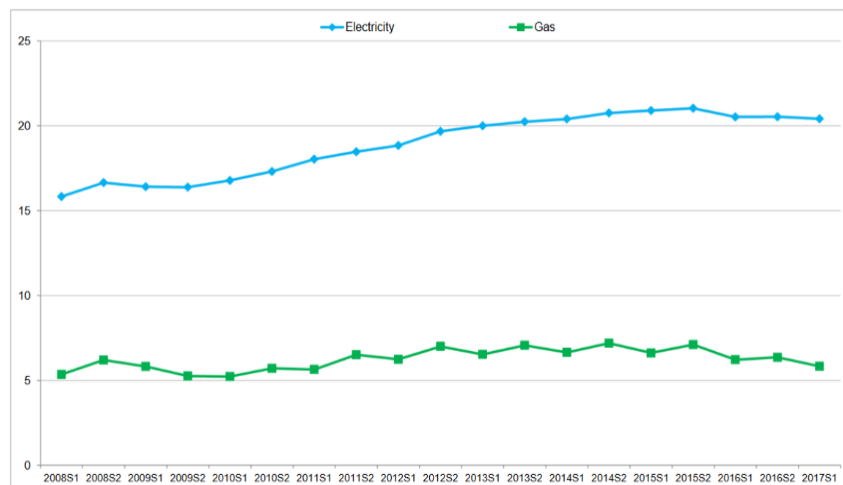

Figure 4 Evolution of household electricity and gas prices in the EU (€ per 100kWh, all taxes and levies included), [10]

Across the EU Member States, the highest increase in household electricity prices in national currency **between the first half of 2016 and the first half of 2017 was registered by far in Cyprus (+22.0%), followed by Greece (+12.8%),** Belgium (+10.0%), Poland (+6.9%), Sweden (+5.5%) and Spain (+5.1%), [10]. In Greece, household needs for **space heating and cooking represent 81%** of the total annual energy consumed, while the household's energy needs are covered by oil and electricity to the extent of 44.1% and 26.8 %, respectively. An estimated 85.9% of the thermal energy consumed is intended to cover the needs for domestic heating. On average, 6.6% of the annual total electricity consumed by a household is used for lighting and 4.9% for space cooling [11].

Opportunity for GAIA BMA

Electricity consumption in Europe has increased by 0.7% (23 Terawatt-hours) in 2017, the third year in a row that overall European electricity consumption has increased. This comes due to the progress in energy efficiency not being able to keep up with Europe's economy recovering, i.e., additional power demands from new growing sectors [12]. So far, many buildings in the EU have installed automation systems through which there is a lack of insights regarding *how* the operations run and *where* electric, water, and gas resources are consumed, rendering them unjustifiably costly for their capabilities. Building management systems on the other hand, provide computer-based systems which integrate a comprehensive range of building services towards controls and monitoring, covering mechanical and electrical equipment, HVAC, lighting, power systems, fire systems and security systems [13].

Global Industry Analysts report that the global market for Building Energy Management Systems is projected to reach US$5.5 billion by 2020, driven by the growing regulatory pressure to curb energy wastage in buildings [14]. Grand View Research, [15], predicts the following for this market:

- The global energy management system market size will reach $58.59 billion by 2022 from $20.49 billion in 2014, growing at CAGR of 14.3%.
- Sensor EMS market components dominated the industry and generated revenue worth USD 7.24 billion in 2014. Software is expected to emerge as the fastest growing component at an estimated CAGR of 16.3% from 2015 to 2022.
- The Power and energy sector contributed the majority of the revenue generated in 2014 and is expected to maintain its dominance over the forecast period to reach a net worth of USD 22.57 million by 2022, at an estimated CAGR of over 13.5% from 2015 to 2022.
- Commercial sector accounts for over 80% of the total installation and is expected to lose share to residential sector over next seven years. Implementation of various new government legislations to promote energy management and control, as well as green building construction initiatives in the UK, Germany and U.S. are anticipated to create lucrative opportunities for industry participants to invest in the residential sector.

An overview of the Building Automation and Control Systems market by region is depicted in the following figure:
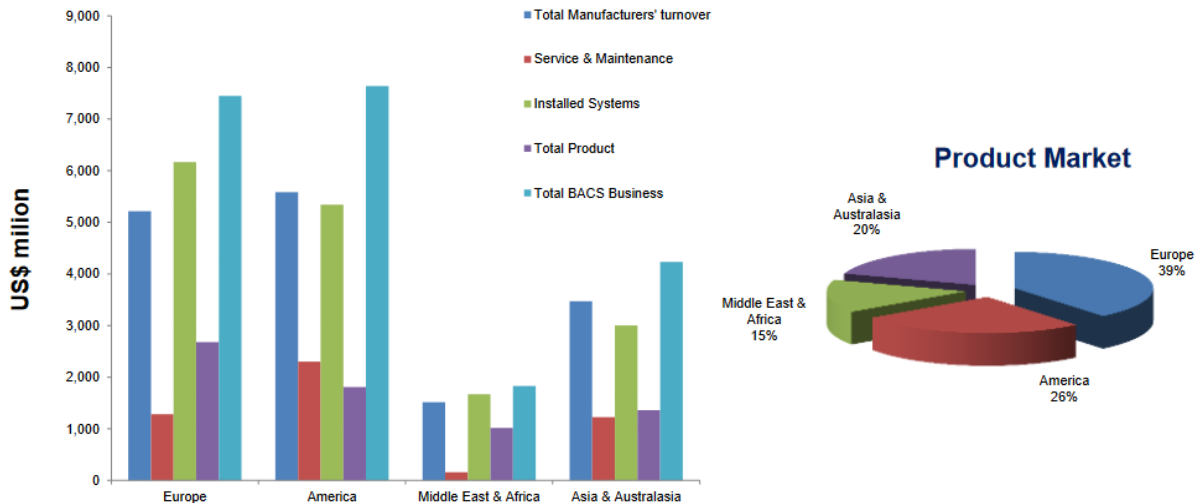
Figure 5 World BACS Market Overview by Region, [15]

Focusing on the home automation system market segment we see that it is growing due to significant growth in IoT applications, reducing costs of home automation systems (owing to technological and other advancements), continuous strengthening of product portfolios for home automation devices by leading manufacturers, and increasing importance of remote monitoring of residential properties, [16]. Markets and Markets, forecasts the global home automation system market to reach USD 78.27 Billion by 2022, at a CAGR of 12.46% between 2016 and 2022.

Under the new, revised Energy Performance of Buildings Directive (EPBD), Smart technologies will be further promoted, for instance through requirements on the installation of building automation and control systems and on devices that regulate temperature at room level. Health and well-being of building users will be promoted, for instance through an increased consideration of air quality and ventilation, [17].

The building services control industry in Europe has developed relatively slowly compared to other industries that use microprocessor-based technologies and communications. One of the principal reasons is *insufficient general awareness*, understanding and appreciation of the importance of HVAC control systems, [18]. GAIA has shown that by affecting the behavioral characteristics of the citizens' interaction with and within the buildings where they live, learn and work appears to have a sizable impact on the overall reduction of the energy consumption [19]. Significant savings can be achieved through reallocation of costs to needed services, when energy consumption is reduced. By actively involving staff of the schools as well as the students participating in the project, we managed to foster to a certain degree a culture of energy conservation.

Competition in the EMS market

In the "European Market of Building, Automation and Controls"[16] the major energy management solutions have been classified according to building size and sector as presented in Figure 6.
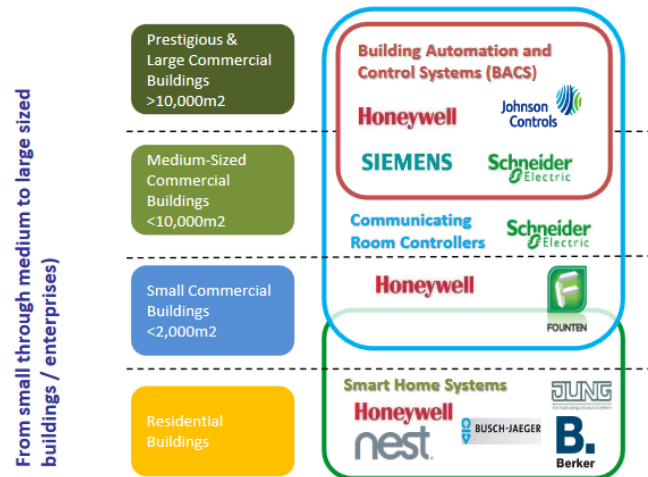
Figure 6 Building Energy Management Systems Competition Classification Examples, [19]

According to Markets and Markets [16], the major companies in the home automation systems market globally are:

➢ Honeywell International Inc. (U.S.)
➢ Legrand (France)
➢ Ingersoll-Rand plc. (Ireland)
➢ Johnson Controls Inc. (U.S.)
➢ Schneider Electric SE (France)
➢ Siemens AG (Germany)
➢ ABB Ltd. (Switzerland),
➢ Acuity Brands, Inc. (U.S.)
➢ United Technologies Corporation (U.S.)
➢ Samsung Electronics Co., Ltd. (South Korea)
➢ Nest Labs, Inc. (U.S.)
➢ Crestron Electronics, Inc. (U.S.)

From our own initial market research, we have come across competitive solutions, whose offerings are summarized in the following table:

Table 1 Building Energy Management Systems Competitive Solutions

Solution	Offering
Energy Consumption Tracker[2]	- add readings manually - compare consumption readings - three predefined meters: electricity, gas and water - list and graph overviews of the energy consumption - add new readings using estimates based on usage in the past

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[2] https://play.google.com/store/apps/details?id=com.swinergy.enusa

	• rename existing meters and define new ones • estimate of expected costs and compare with a target • choose between automatic or manual setup of meter resets
Home Energy[3]	• historical or real-time total power consumption overview • historical or real-time appliance-level power consumption • appliance power cost calculation • scene or profile-based or manual switching of appliances
Energy Consumption Analyzer[4]	• keeps track of energy consumption • add meters for gas, electricity, or water • calculates the average normalized rate of consumption per hour, day, week, or month • draws a graph showing the consumption rate over time • cloud sync via google drive • virtual meters can be used to display the sum of individual meters and do simple unit conversion • meter data can be imported from and exported to CSV files
AEI Home Energy Manager[5], [24]	• month-to-date energy consumption and costs • forecast for monthly bill • track consumption on an hourly basis, a daily basis and a monthly basis • setup alerts when your bill has reached certain amounts.
Chai Energy[6]	• comes with a free mobile app • calculates how much energy is being used • predicts energy bill • customized energy conservation tips
MyMeter[7]	• manages end-use demand and consumption • interactive charts and heat maps toggle between interval, hourly, daily and monthly to help users diagnose expensive or wasteful usage patterns. • plotting usage in comparisons to historic data, local temperature, and similar neighbouring properties further helps to identify trends and the opportunity for energy improvements. • tools for benchmarking weather-normalized energy use intensities against similar property types • tools to identify appliance replacements, renovations, and occupancy-based events, creating their own personal journal of key energy-use related events and the impact on energy use.

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[3] https://play.google.com/store/apps/details?id=com.greencomnetworks.homeenergy

[4] https://play.google.com/store/apps/details?id=at.topfen.ecas

[5] https://play.google.com/store/apps/details?id=com.homeenergy.manager

[6] https://chaienergy.com/

[7] https://play.google.com/store/apps/details?id=com.acceleratedinnovationsllc.mymeter , http://mymeter.co

myMCS building energy software[8]	• captures energy data from a variety of sources (smart meters, sensors, utility bills, building energy management systems, etc.) and collates the information in a central database • structures the energy data and transforms it into relevant metrics, allowing for analysis, comparison and benchmarking of buildings over time • measures, monitors and benchmarks energy performance • identifies cost saving opportunities, and carries out improvement projects (lighting, HVAC, insulation) and tuned maintenance • raises awareness among building users to stimulate energy savings • analyses and optimizes utility bills • reduces energy needs by optimizing space usage
enteliWEB,[9]	• web-based application • customizable energy management dashboards and energy reports • task-driven alarm management made simple with intelligent visualizations, alarm assignments, and operator comments • system dashboards aggregating system graphics, alarm management, energy information, and more, into a single dashboard screen. • high level information in simple graphical formats • scheduled report emails deliver information when needed, without having to login • multiple Independent Sites can be managed from a single login • graphics can be displayed side-by-side other widgets in dashboards or as full page stand-alone graphics. • version independent software allows organizations to operate an entire WAN without having to worry about firmware versions in the hardware • browser independence allows the choice of virtually any browser, including Internet Explorer, Firefox, Chrome, and Safari.
BuildingOS[10]	• uses real-time data to identify operational efficiency opportunities and drive action from the data, enabling ongoing savings over the long-term • powerfully and visually displays scheduling inefficiencies • detects when your building startup or shutdown times change or baseload use increases • manages peak demand • notifications translate analytical insights into instant savings • detects issues and abnormalities-automated texts or email messages

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[8] https://www.mcssolutions.com/energy-management

[9] https://www.deltacontrols.com/products/facilities-management/mobile-user-interface/enteliweb

[10] https://lucidconnects.com/solutions/building-efficiency

Honeywell Total Connect Comfort[11]	- allows users to remotely monitor and manage their heating and cooling system – anytime from anywhere - works with Honeywell Wi-Fi Thermostats and with Prestige®, Prestige® IAQ, Wireless FocusPRO® and EConnect™ Comfort Systems when used in conjunction with Honeywell' s Internet Gateway. - view and change the schedule (for thermostats that support this feature) - utilize the Demo Mode before purchasing a thermostat - view and change heating and cooling system settings - view and set the indoor temperature - view and change system fan (for thermostats that support this feature) - view and change humidifier and dehumidifier settings (for thermostats that support this feature) - view 5-Day weather forecast - view outdoor temperature and humidity (when used with an outdoor sensor) - access multiple smart thermostats - access multiple locations if more than one system is registered - view thermostat alerts such as high or low temperature

4.2 The market of educational methods and materials

According to current estimations [21], the global online education market is projected to witness a compound annual growth rate of 10.26% to reach a total market size of US$286.62 billion by 2023, increasing from US$159.52 billion in 2017, while platforms that facilitate learning through gaming are gaining popularity.

Indeed, the market for **educational content and educational publishers** is transforming from book-driven markets and business models into interactive online learning platforms. The GAIA Challenge as an educational learning platform was designed to be both compelling and fun to interact with for students and designed to fit and understand the needs and challenges of teachers to integrate digital tools in classroom settings in a flexible and interdisciplinary way. The GAIA Challenge is available free, in the German-speaking market the budgets are still widely connected to books, so the GAIA Challenge is and will remain free of charge for schools. However, many countries -including Austria and Greece- are working on digital roadmaps aiming at enriching or building up digital learning environments for school usage. The GAIA Project as well as the Educational concept fits in there nicely and support important action areas such as mobile learning, IT-competences, creative-problem solving, coding/making, game-based learning etc. The GAIA partners will reach out to national players in the educational market such as educational publishers, ministries of Education, learning labs to tie cooperation and aiming to create license packages for the GAIA projects in different countries.

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[11]https://info.mytotalconnectcomfort.com/en-GB

In the context of Greece, in particular, where the majority of the school environments engaged in the GAIA project are based, both the thematic focus of GAIA (energy efficiency) and the experiential learning-focused educational approach it proposes are gaining in popularity in the world of education. While the Greek educational system is characterised by strong centralisation and resistance to change, a growing consensus has been developing in the world of school education, policymaking and the society that more flexible and innovative teaching and learning approaches focused on addressing real-life problems and the major challenges of humanity are needed. Reasons that make the prospects of GAIA's proposed practices for energy efficiency in schools favourable to be taken up by school communities include the fact that many public Greek schools have already actively participated in the project, while the project coordinator's, CTI's, organic link to the Greek Ministry of Education, in a positive influence in that direction. Both of these contribute to a feeling of "ownership" of the GAIA project concepts and outcomes in the world of school education in the country.

4.3 Current status of the IoT market

The state of technology in the IoT market is very advanced, compared to what it was only 20 years ago. The combination of billions of interconnected IoT devices and the upcoming 5G network era, are about to drive a profound change in the way computing workloads are deployed. It is expected that there will be more than 5.600 million smart sensors and connected IoT devices across the globe by 2020. Furthermore, the data generated by these devices will be to the tune of 5.000+ zettabytes, while the IoT market size is expected to reach $724 billion by the end of 2023.

The ICD forecasts that in Central and Eastern Europe will be spending on the IoT $11.2 billion in 2018, an increase of 15.5% from 2017 sustaining a compound annual growth rate of 18.8% through the 2017-2021 forecast period, thus surpassing the $20 billion mark in 2021. With IoT solution development rapidly accelerating, enterprises are actively investing in tools and technology to increase security, improve productivity, provide higher levels of service and reduce maintenance costs. Concurrently, SMEs want to enhance their product line and services, integrating edge into their products to provide improved experiences for their customers, but face many challenges, which can affect overall IoT deployment costs and timing. As such, enterprises are using IoT edge platforms to improve their critical business process while overcoming these deployment challenges.

Western Europe and North America lead the pack in the fast-growing market of IoT edge platforms. IoT edge platform revenue will grow at a sharp 81% in 2018, with 35% of revenue generated from enterprises in Western Europe. Sectors of greatest interest to IoT edge platform vendors include industrial, manufacturing, automotive, transportation and smart cities.

5.   Innovation Roadmap

GAIA partners have surveyed the societal and market status and have realized that both society and market are mature and ready to accept new solutions and embrace energy-efficiency related campaigns at educational settings exploiting the outcomes of the GAIA project.

All GAIA partners have:

- Committed to support and sustain the developed solutions post project and
- Defined concrete plans for exploitation in the societies and market of their interest as detailed in chapter 6.

With respect to sustainable innovation management, GAIA targets

- ✓ Sustainability with respect to energy efficient behaviour embraced by the communities engaged in GAIA pilots, also referred to as **Sustainable Energy Efficient Behaviour (SEEB)**
- ✓ Sustainability and expansion of GAIA impact which constitute social innovation, also referred to as **Sustainable Social Innovation (SSI)** and
- ✓ Sustainability with respect to further and commercial/scientific exploitation of the GAIA innovative outcomes, also referred as **Sustainable Technological and Scientific Innovation Exploitation (STSIE)**

In the following two sections, we briefly describe the short and long term sustainability plans where by "short" term we refer to the plans for the two years following project end (till June 2021) and "long" term refers to three years and subsequent after the project end.

5.1 Short term sustainability plans

The short-term sustainability plans of GAIA are formulated along the above-described three sustainability and innovation axes.

Sustainable Energy Efficient Behaviour (SEEB)

GAIA partners intend to **continue supporting the schools** that have been included in the GAIA pilots for two more years. This implies that the installed sensors and their readings will be available through the BMS and the currently available content will be available through the GAIA challenge. The registration of new users (as new pupils/students and teachers arrive in the schools).

EA and SK are committed to use GAIA material in their teaching activities with the pupils.

Sustainable Social Innovation (SSI)

GAIA partners have already made plans for **expanding the fleet of supported schools**. As discussed in chapter 6, CTI has already assured the availability of national funds in Greece for installing the necessary infrastructure in additional schools in Greece. In parallel, Synelixis has already discussed with a Greek energy provider on the opportunity to fund further installations in Greek schools and organization of contests.

OVOS, the Austrian GAIA partner is in contact with the national ministry which is consider devoting funding to develop **an Austrian version of the GAIA platform**. Furthermore, GAIA material has already been agreed to be included in the national open material libraries.

EA has also decided to repeat the **contest among teachers** it organized in 2018 in the following two years as a means towards further raising the consciousness of teachers and their awareness of the available materials.

Sustainable Technological and Scientific Innovation Exploitation (STSIE)

Sparks and OVER, apart from continuing supporting the GAIA platform, they have concrete plans for offering their solutions to their customers soon after the project end. SPARKS IoT platform is already mature and the smart city/energy vertical is one of the five verticals strategically targeted by SPARKS. OVER is already installing OverBoard (child-product of NanOmeter) and is extending its installations continuously. Synelixis is planning to promote its BMA as a complete solution named SynErgy in Balkan countries for educational and small enterprise buildings. CNIT mainly aims at scientific exploitation as detailed in chapter 6.

The results of GAIA pilots are turned to **strong promotion assets** for all the above activities. Namely, t

- ✓ the quantitative results achieved during the GAIA pilots (e.g. up to 39% saving in the school in Prato within a student project)
- ✓ The feedback collected from the teachers and principals.
- ✓ The feedback and engagement of students

(Further details are provided in D4.3 and will be used to create the promotional and supporting materials for marketing GAIA solutions.)

5.2 Longer-term sustainability plans (more than three years after project end)

The longer-term sustainability plans of GAIA are formulated along the abovementioned sustainability and innovation axes, including **the continuation of all the above activities** for certain periods of time, plus additional ones. In the sequel, we focus on the additional activities planned.

Sustainable Energy Efficient Behaviour (SEEB)

GAIA partners intend to develop

- Educational material for additional curricula, to cover additional target groups
- Educational material in additional languages, to cover additional societies
- Additional gamified content, to strengthen engagement and meet preferences of additional audiences
- New components to offer further intelligence to the BMA users

Sustainable Social Innovation (SSI)

The new materials and gamification concepts mentioned in SEEB above is inherently enabling social innovation. The families of the students and other groups (as e.g. the bank personnel clustered per branch) will be targeted. Thus, with the new materials and technological developments, new campaigns will be possible to penetrate additional societal groups. The target is to reach tens of thousands of citizens.

Sustainable Technological and Scientific Innovation Exploitation (STSIE)

The longer term innovation plans of SPARKS, OVER and SYNELIXIS are not disclosed in this document as on one hand, this is sensitive information and on the other hand, as SMEs these three partners are flexible in designing and developing components that match the needs of their customers. Hence, OVER currently expanding and covering bank offices may follow an innovation direction tailored to its customers, which may be completely different from the direction that will be followed by SYNELIXIS that mainly target educational and small enterprise buildings in the Balkans.

6.   Individual exploitation plans

6.1 Computer Technology Institute and Press "Diophantus"

Overall, the exploitation of project results with respect to CTI will follow two main directions, **teaching and research**. CTI is a private not-for-profit research institute, overseen by the Greek Ministry of Education, Research and Religious Affairs. As such, CTI's mission includes aims such as educational excellence and dissemination of its research results at the educational domain. Its close relation to the ministry also allows for the easier application of this vision in practice. Moreover, due to its nature, CTI has opted to not commercialize its output related to GAIA and follow an open-source focused approach. **All software developed exclusively by CTI is already available online, as will any future expansions to it.**

Furthermore, CTI has a both a short- and a long-term strategy to utilize the results of the project in the context of these two directions. In this sense, CTI is reaching out to a number of communities to create a critical mass of end-users, in order to provide a meaningful outcome for the project in terms of impact. This end-user community is being forged by continuously expanding the network of schools that are actively linked to the project, establishing links with other relevant H2020 projects, disseminating the educational outcomes of the project in related educational networks, and also by expanding the IoT infrastructure and software ecosystem of GAIA to a degree that it can support multiple aspects of sustainability education and practice. This infrastructure is a valuable asset to CTI that will be utilized in many different contexts, enabling applied research in a number of current topics.

Apart from the obvious potential uses in terms of educational outcomes, it is utilized as a means to enable large-scale studies of building performance and energy-related behavior. CTI also plans to integrate additional capabilities to the infrastructure to enable crowdsensing applications, as well as integration of measurements to local government platforms, to kickstart further synergies at a citizen level. Creation of **datasets** regarding these aspects and public availability of such data is another direction that will be explored by CTI in the coming months and especially following the end of the project.

In terms of the time period for continuing to support the project outcomes, especially with respect to the schools in Greece, CTI will continue to operate the infrastructure and toolset, as well as support educational activities until at least December 31st, 2020. CTI has already communicated this prospect to the schools that participate in the project, in order for them to continue planning relevant GAIA activities in the future as well. **CTI has also secured additional funding to provide extensions of the infrastructure in Greek schools in the near future.** This will further enhance both the size of the infrastructure, as well as the diversity of sensed phenomena utilized in the educational aspects of the project. In this context, it will continue to add to the expected impact of the project, since new student classes will have the opportunity to use the GAIA methodology and toolset. Having in mind the number of schools in Greece collaborating with the consortium, this will result to several hundreds to thousands of additional new students having a direct experience with the project's results.

In terms of licensing, CTI has followed a strict open-source licensing policy from the start of the project. The utilized license for CTI's software is the BSD license, which makes it easier for third parties to create commercial products based on licensed software, in comparison with other popular licenses. All software

created by CTI for the project is available through the project's repository[12] on GitHub, on which it is maintained. The following table lists the components produced by CTI and made available through GitHub, using the BSD open source license:

Table 2 Technical components

Products / Technical Components	Short description	Exploitation plan
GAIA Viewer	Android application for viewing GAIA data on site, providing an additional means for teachers and students to implement educational activities during class time.	The app will be actively used until the end of the project by educators and students while implementing educational activities. It will continue to be supported after the end of the project by CTI in order to engage additional school users in the future, while CTI will also explore ways that such apps will enhance the sustainability and maintainability of the IoT infrastructure.
GAIA Touch	Software for implementing interactive installations based on GAIA data.	The software and expertise generated will be utilized in further developing related solutions by CTI, as part of its software toolset.
GAIA Workshop / GAIA Pi	Hardware platform and software libraries for the Raspberry-pi based GAIA educational lab kit, enabling teachers to implement a range of hands-on IoT-based lab activities.	The workshop activities will help to engage additional end-user communities in the future, helping to create a critical mass for CTI's educational output and GAIA-related software.
GAIA AR extensions	Smartphone/tablet augmented reality app, providing an additional means of interfacing with GAIA's data during lab kit activities. Currently at prototype stage.	In a similar fashion to the GAIA viewer app, this will help in further engaging the end-user community, as well as provide an additional means to inspect and maintain the installed IoT infrastructure, adding to ease of maintenance.
GAIA Bot	Chatbot providing an additional end-user interface with GAIA measurements. Currently at prototype stage.	In a similar fashion to the GAIA viewer app, this will help in further engaging the end-user community, as well as provide an additional means to inspect and maintain the installed IoT infrastructure, adding to ease of maintenance.

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[12] https://github.com/GAIA-project

GAIA IoT Nodes platform	Hardware and software platform for IoT nodes used in GAIA's infrastructure, including nodes installed inside classrooms and electricity consumption meters.	As argued in this section, CTI's open source approach to the software and hardware used in the project, adds many possibilities to exploiting the project results.

Table 3 Learning material

Component	Short description	Exploitation plan
GAIA Educational lab kit	Educational material to support GAIA's educational lab kit activities, organized in a series of workshops covering aspects like energy consumption, relation of temperature and humidity inside buildings, energy audits for buildings, etc.	CTI will utilize this content as a means to engage end-users in the educational community. It also presents a structured approach that can be used as part of research focusing on the educational community and citizen-based sustainability projects.
GAIA Handbook	A booklet containing selected parts of GAIA's educational content output meant to be used as a set of good practices and structured approaches to sustainability and energy savings over the GAIA approach.	CTI will utilize this content as a means to engage end-users in the educational community. It will be printed and disseminated to around 100 schools in Europe, apart from making it available online. It also presents a structured approach that can be used as part of research focusing on the educational community and citizen-based sustainability projects.

With respect to the **IoT infrastructure of CTI**, it has grown from being at the start of the project a large-scale deployment in several buildings, to one of the biggest IoT infrastructures in the educational sector currently available in Europe. Currently, the number of available sensing endpoints is close to **1200**, while being spread to 23 buildings in Greece, Italy and Sweden. We are not aware of many similar existing infrastructures in Europe for research purposes that has the size and spread of GAIA's deployment. The maturity of the hardware part of the infrastructure has also benefited tremendously by being used by the educational community, offering the opportunity to CTI to enhance the quality of the related measurements, as well as its overall reliability. Combined with the implemented integration with a number of the consortium partners' systems, this has enabled CTI to currently operate a mature IoT infrastructure, regardless of business domain. CTI can thus confidently state the IoT infrastructure part of the project has reached a **TRL9 level of maturity**.

CTI has also utilized its experience in interactive installations to implement a number of GAIA installations in several school buildings in Greece. These installations are being co-designed and co-implemented with the students and teachers of these schools, and will utilize measurements from the GAIA infrastructure to implement a custom theme as proposed by the schools themselves. The implementation of GAIA's backbone allows near real-time response to specific aspects of these installations, allowing for a range of options regarding interactivity with students inside the school buildings. The implemented interactive installations design and related code will be made available on GitHub after the end of the project.

Moreover, the consortium has been actively trying to reach out to other communities and H2020 projects, in order to find a greater audience for its results, with CTI spearheading this approach. **CTI has already established links with four European research projects**, with the prospect of further expanding collaboration with other parties, in order to enhance the impact of the project. The linked projects focus mostly on smart city aspects, as well as IoT educational and business aspects, thus being a good match for the intended audience for the project. In certain cases, like UMI-Sci-Ed, such projects provide an audience for GAIA that can directly use GAIA's output and integrate it into their workflow. There is also synergy with two H2020 projects with different funding framework, exploitation of funding in areas beyond contractual obligations, wider impact, as well as use a more structured approach for disseminating GAIA's own educational content.

UMI-Sci-Ed: One such direction is cooperation with the UMI-Sci-Ed[13] project. The main goal of UMI-Sci-Ed is to raise career prospects in educational subjects related to Diverse Computation, Mobile Computing and Internet of Things. The population target group is 14-16 year old school pupils and information-education-outlook is through interventions in STEM courses. The conceptual tool is Communities of Practice (CoPs), which include students, teachers, academics, business and labor market participants, while the technological tool for supporting and managing CoPs is the UMI-Sci-Ed platform. Regarding benefits for collaboration between the two projects, UMI-Sci-Ed's existing and prospective users are estimated at 1000 by the end of the project (31/05/2018, same date as GAIA), while we also offer our own user community.

 OrganiCity: OrganiCity was a H2020 project that provided a platform for smart city experimentation in 3 European cities (Santander, London, Aarhus) and ended on July 2018. It also provided a means to federate data sources from IoT infrastructures in other cities and projects. GAIA is listed as part of the OrganiCity's network of collaborating projects[14], since a number of data sources related to readings of environmental parameters the school buildings were fed into OrganiCity data repositories, and were made available through the Urban Data Observatory[15] during the experimentation periods for the project.

E2Data: E2Data[16] is an H2020 project focusing on big data applications and cloud computing over heterogeneous hardware resources, for which energy and sustainability in school buildings has been selected as one of the project's use cases. In this context, measurements from GAIA school buildings will be used to drive the application of E2Data's software stack in the energy domain, testing the performance

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[13] http://umi-sci-ed.eu/

[14] https://organicity.eu/vision/adjacent-networks/

[15] https://observatory.organicity.eu

[16] https://e2data.eu/

of related algorithms. E2Data will support the expansion of CTI's IoT infrastructure in Greece in order to accommodate larger-scale scenarios with additional sensing points. After the end of GAIA, the expanded IoT infrastructure will be made available to the school participating currently in the project, ensuring an even larger-scale application of the platform by the GAIA consortium.

EsmartCity: EsmartCity[17] is a project funded under Interreg MED. Its main objective is the improvement of the innovation capacity of the cities in the MED region by creating innovative ecosystems. To this end, the project aims to pilot the ideas of the Smart City, using digital technologies and energy efficiency technologies to provide better services to the citizens with less environmental impact. The project stands up to the challenge of enhancing the necessary public authority/citizen pull to match the already existing technology push driving at large the Smart City market. To this end, it will enroll to a multinational pilot deployment in the MED area related to the application areas of intelligent districts, smarter energy and smarter lighting. Furthermore, it will test its sustainability with experimentation and co-creation scenarios and intervening in MED territory innovation policy change strategies. Its pilot testing comprises energy efficiency in public buildings in Western Greece, Milan (Italy), Palmela, Setubal and Sesimbra (Portugal), and in this context measurements from GAIA's schools in Western Greece will be utilized to expand its scope.

Scientix: Scientix promotes and supports a Europe-wide collaboration among STEM (science, technology, engineering and maths) teachers, education researchers, policymakers and other STEM education professionals. This is exactly the intended audience for GAIA and CTI is actively engaging with this community through the channels provided by Scientix. More specifically, GAIA has already a presence in Scientix[18], while also participating at the Greek[19] branch of the conferences organized by this community. The GAIA approach has been presented to the Greek Scientix community in terms of educational content, which is based on the use of real-time environmental data from school buildings and their integration into classroom educational activities. GAIA intends to make its educational scenarios available through the official Scientix portal as well.

Local government level: CTI has been actively discussing the prospect of utilizing the existing GAIA infrastructure in GAIA schools and offer its datasets to the Prefecture of Western Greece, as a means to provide remote monitoring in terms of energy consumption and environmental parameters. Energy costs of public school buildings in Greece are paid at a local government level. Although remote monitoring of energy consumption in public buildings in Greece has begun to be utilized more systematically, the scale of such an endeavor means it will take some time until it reaches a satisfactory scale. GAIA's infrastructure in the greater area of Patras provides such information, and along with future planned expansions to the range of utilized sensors, this will open additional possibilities to broaden GAIA's impact at a local level, while also ensuring the continuous operation and sustainability of the project's infrastructure.

Greek Ministry of Education, Research and Religious Affairs: As mentioned above, CTI has close links with the Greek Ministry of Education, Research and Religious Affairs. It will actively pursue the dissemination

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[17] https://esmartcity.interreg-med.eu/

[18] http://www.scientix.eu/projects/project-detail?articleId=689542

[19] http://gaia-project.eu/index.php/en/2018/09/06/the-gaia-at-the-panhellenic-scientix-congress-in-athens/

of the project outcomes to the Greek educational community, with a focus on finding schools that will utilize GAIA's results and integrate part of the produced educational material into their curriculum.

European School Community: In terms of addressing the broad European educational community, CTI together with EA and OVOS has contacted communities in Austria, Germany, Greece and Malta, in order to reach an even larger educational audience and maximize the impact of the project.

Commercial aspects: Although CTI will not seek direct commercialization of the project outcomes, it will explore ways to broaden its impact and simplify the availability of the produced outcomes to the target communities. Such measures include exploring collaborations with makerspace hardware manufacturers that use an open source approach, like Seeed Studio[20], in order to provide GAIA "compatible" solutions to other communities. In this sense, it will be easier for interested school communities to get the IoT hardware required at an infrastructure level.

6.2 Söderhamns Kommun

In the GAIA-project, Söderhamns Kommun (SK) installed infrastructure in one of its school buildings, measuring:

- Luminosity in the classrooms.
- Temperature in the classrooms.
- Noise in the classrooms.
- Motion in the classrooms.
- Electrical energy consumption for the building.

During the project, SK has used this infrastructure to increase knowledge and awareness among its staff and students. It will continue this work in the future. One example of activity is to let students monitor the luminosity in one classroom to see if the lights are turned off when they are not needed. Another activity is to let students monitor the temperature in one classroom to see if we can lower it to save energy.

The infrastructure has also helped SK to locate energy "hogs" in its GAIA building. The two largest ones were:

- The heating of the ventilation air during winter.
- The lightings.

Because of the findings stemming from the GAIA project, SK will install heat exchangers on all ventilation systems that are not already equipped with exchangers. SK will also change all lighting inside its building premises. Those actions are taken for the whole school – not just the building with GAIA infrastructure. The installations have already started and will be finished within 2019. Those actions will save a lot of energy for the school with substantial long-term financial benefits, as well as in the near future.

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[20]Seeed Studio, the IoT hardware enabler, https://www.seeedstudio.com/

The lightings SK is currently installing are LED with motion sensors. They also adjust their power automatically to only create the luminosity needed. This action will **save more than 80%** of our energy consumption for lights.

During the GAIA-project, many students have **played GAIA-Challenge. This act has helped to make the students more interested in energy saving.** In the future, we plan to continue using the game for this purpose. We will arrange local contests between classes to create more interest for the Challenge, and thereby make the students more interested in energy saving.

6.3 National Interuniversity Consortium for Telecommunications- CNIT

The main exploitable results for CNIT within GAIA are listed in the tables that follow. More details on the exploitation plan is provided hereafter.

Table 4 Technical components developed by CNIT

Products / Technical Components	Licensing terms	Exploitation plan
Recommendation Engine	Apache v2	CNIT aims to disseminate scientific results in international journals, in addition to a contribution already presented in a conference and published in the proceedings. CNIT also aims to use and extend the software in future research projects.
GAIA Plugin for Node-red	MIT	Plugin for interfacing with the GAIA platform using the Node-Red tool within the Learning activities in the table below.

Table 5 Learning material

Knowledge	Licensing terms	Exploitation plan
Node-red Learning activities	CC-BY	Learning activities focused around the use of SensorKit and the GAIA platform in computer science classes leveraging the NodeRed tool. CNIT will exploit this knowledge in future research projects and education activities in high school and university courses.

Node-RED[21] is a flow-based development tool for visual programming for wiring together hardware devices, APIs and online services. It provides a browser-based editor that allows users wiring together

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[21] https://nodered.org/

flows using the wide range of nodes in the palette. Flows can be then deployed to the runtime in a single-click. JavaScript functions can be created within the editor using a rich text editor.

CNIT developed a set of nodes, called GAIA Nodes for interfacing with the GAIA Platform (mostly Sparkworks API v.1).

In the following table are examples of related learning activities, with a brief description:

Table 6 Node-red Learning activities

Learning Activity	Duration	Description
Introduction to Node-Red	2 hours	- Understand the meaning of the Internet of things - How to place Flow-Based Programming in the scenario of programming paradigms Recognize the role of application-level protocols like HTTP and MQTT - Understand the basic elements of Node-RED
GAIA nodes	2 hours	- Understand the importance of being able to expand Node-RED with new nodes. - How to use the available Gaia nodes. - First approach to the JavaScript language.
Virtual sensors	2 hours	- Understand the role of temperature, humidity and brightness sensors. - Learn how to manage the data collected by the sensors.
Design and implementation of a web dashboard	4 hours	- Familiarize with HTML - Learn how to design and make a small widget.

The exploitation of project results will follow two main directions: teaching and research.

a) As regards teaching, knowledge and expertise developed through the project and case studies emerging from the project trials will be used in graduate and undergraduate education programs on IoT platform and application protocols. The outcomes and the methodologies adopted in the project will be presented to students of master degree courses and they will represent the starting point for possible research activities within master degree thesis and PhD thesis. Monitoring data gathered through the project, especially data concerning the Gramsci Keynes school in Prato and accessible through REST APIs could be exploited in students' project to let students get experience in programming using real monitoring data.

b) Research exploitation will be both short and long term. In short-term the outcomes, the methodologies and the competencies acquired from the participation at the project allowed CNIT to consolidate competencies in the Web and Internet of Things domain, energy efficiency and cooperation with secondary level schools. CNIT will exploit the valuable network of competencies made by the project partners, to create and contribute to new and fruitful collaborations fostering cutting-edge research activities on GAIA related topics. Such research

project might focus on ICT and tools (e.g. IoT platform, rule management) as well as application-oriented activities focusing on extending the experimentation and the adoption of GAIA technologies and methodology in additional schools and/or continuing the experimentation within Prato.

6.4 Synelixis Solutions SA

Product/ Solution Presentation

Synelixis, building on the outcomes of GAIA, plans to offer an **integrated solution for building energy management**. The aim is towards a product that will allow the user to track and control their building's energy consumption remotely through mobile phone, tablet or laptop at low cost and additionally receive alerts under specific user-defined conditions to trigger appropriate action. We give this product the (working) name SynErgy. This solution capitalizes on state-of-the-art technology to enable remote monitoring of the environmental and indoor conditions (temperature, humidity, wind speed, rain), of the energy consumption at several point in the building (through power meters) and other indoor conditions like motion/presence. SynErgy will also allow for manual uploads of home energy sources values: electricity, oil, natural gas.

SynErgy allows:

➢ Monitoring what is happening in the building they care about; currently, temperature, humidity, motion, wind and energy consumption sensors are supported;
➢ Access data analytics of al installed and virtual sensors and parameters in different timescales; the analytics can also be exported in different formats.
➢ Identification of saving potentials and malfunctions in their building.
➢ reception of recommendations and alert based on predefined rules
➢ Uploads of energy consumption in typical formats combined with metadata of the building.
➢ Virtual sensing implementation: the user may define a certain factor and he (or any other authorised person) can enter values, which can then be plotted/visualized.
➢ Comparisons between different time periods.
➢ Comparisons with other buildings in the same region; comparisons of consumption per square or cubic meters allows for identification of improvement potential.

The application then processes the data and provides benchmarks on the building performance going beyond state of the art energy management systems by producing detailed benchmarks not only for energy consumption, **but also indicators for peak and base loads on different days of the week**, operation schedules of the building etc.

Analysis of historical data will be provided via attractive diagrams and important metrics such as mean values, peak and base loads depicted in a daily, weekly or monthly basis according to the user preference. Communication with sensors placed in the building tracking energy consumption, temperature and humidity levels in order to automate the procedure will also be possible. Alerts will notify the user when rules are triggered via text or email allowing them to take appropriate action. A social networking feature for users to compare similar buildings is also feasible.

Market potential

SynErgy targets the market of EMS (which is huge as described in chapter 4) and more specifically this of buildings for which the available budget cannot cover a fully automated system like these offered by large EMS vendors. Synelixis considers that the stronger potential for SynErgy is found first in Greece and the Balkans, and then in the rest of Europe.

The PEST (Political Economical Social and Technological) Analysis for such a solution is presented in Figure 7.

Figure 7 BMS Application PEST Analysis

In Figure 8, we have conducted a SWOT Analysis depicting the application's status in the market:

Figure 8 SynErgy's SWOT Analysis

Marketing Plan targeting school buildings

Positioning

Since the GAIA project focuses on the educational community, Synelixis' application can extend this reach towards school building managers in the rest of Europe as well. The message to be conveyed is that by providing a simple input of data – building information, energy information, sensor input, and participatory sensing data – the application offers an array of services while providing interoperability and integration with current building systems towards energy efficiency and sustainability.

The principal targets for dissemination and potential user groups are:

- Schools.

- Universities in Athens.

- Municipalities - starting with those that have already embraced ICT as a means to improve the citizens' life, such as e-Trikala.

The main offerings of such an application are summarized in the following table:

Table 7 SynErgy's Application Offerings

Installation	- no need to install specialist software and users can log into the system from any location - can be configured to customer's needs
Building manager	- alarm features are built in to provide text, email or audible alerts - comparing with other similar buildings - improving the building's energy performance and usage
Data analysis	- detailed reports and charts - identify trends and anomalies - compare energy use and set targets against indoor and outdoor factors such as temperature and humidity - out of character consumption - indicators for peak and base loads - analysis of historical data
Cost	- low cost - identifying cost saving opportunities
Sustainability and Comfort	- raising awareness among building users to stimulate energy savings - maintaining occupants' comfort - reducing a building's carbon footprint and improving its sustainability

Promotion

Synelixis can disseminate SynErgy through its private networks, updates on its website and Social Networking accounts and other means, as presented in the following subsection, in conjunction to any joined promotional actions.

Marketing plan for other buildings

Positioning

Synelixis will offer SynErgy as a useful tool for building owners and household managers to keep track of their energy usage and aid them in minimizing their utility bills. SynErgy will cover the consumers' needs efficiently and at minimum cost, thus ensuring its place in the market.

In order to be certain that an innovative and useful product is created, apart from the competition analysis, the consumer's point of view needs to be respected. This we have envisioned and are presenting in Table 8 along with SynErgy's value proposition.

Table 8 SynErgy's Value Proposition

End User standpoint	SynErgy Features	SynErgy Value
Needs • Reduce energy bills • Reduce waste	• Tips and hints for decreasing energy usage	
Wants • Tools for automated monitoring with simultaneous targeting and alarm setting • Data analysis to: • identify waste • highlight areas for improvement • benchmark with similar buildings • Low cost solutions • Solutions which could communicate with any tools they may already have been installed	• Wireless communication with monitoring tools (sensors) for automated upload of values • Analysis of historical data • Data presented using attractive graphics - daily, weekly, monthly diagrams • Peak, base loads, mean values identification • Out of character consumption marking • Temperature and humidity readings apart from energy • Rule setting • Alerts when triggered • Comparison with other similar buildings	• Aids in decrease of energy bills • Aids in identifying cost saving opportunities • Raises awareness to reduce energy waste • Improves home's energy performance and usage • Increases user comfort level • Aids in improvement of home occupants' health

F **e** **a** **r** **s**	• Lack of easy access to the application • Complicated installation • Data security • Added costs	• Login to the application from any desktop, laptop or mobile device • Manual upload of energy consumption values (electricity, oil, natural gas) • No added costs	

Promotion

Synelixis will comfortably promote SynErgy at first through its website and Social Networking accounts (Facebook, LinkedIn, and Twitter). In the course of the product's life, Synelixis will consider traditional promotional acts such as brochures and publications to relevant magazines and specialised blogs, as well as the possibility to present SynErgy to relevant events.

The possible promotional activities are presented in the tables that follows:

Table 9 SynErgy Promotional Activities

Method	Benefits
Online marketing *Website updates* *Online brochures* *Social Networking Sites* *Specialised App blogs* *Online magazines* *Google Universal app campaigns*	• Connect the application to the brand • Low cost • Inform our current followers • Reach a wider audience • Facebook customised promotional plans • Reach targeted audience (blogs) • Receive positive user reviews • Promote applications across Google and its networks: • Google Search Network: Google Play, Google Search, Google search partners • Relevant pages or content on YouTube • Google Display Network
Publication in physical magazines Physical brochures	• Present the application's features to a wider audience • Attract targeted users • Connect the application to the brand • Offer details on the features and uses
Conferences Events	• Present SynErgy to the scientific community • Attract citizens in specialised events

Financial Planning

Synelixis considers that to be able to deliver SynErgy as a market ready solution, it needs:

- Improve the front-end design software a) to be more attractive and intuitive, b) to cover additional languages and c) to integrate actuators apart from sensing devices;
- Negotiate with SPARKS on the price and SLA for the backend platform maintenance, upgrade to support actuators and regular support /use;
- Negotiate with home automation hardware providers (whose products have already been integrated in or could be potentially integrated to the GAIA platform) on prices for sensors, power meters and actuators.

Synelixis is expecting to create revenues from the following sources:

a) Providing (delivering and installing all software and hardware components of) the integrated SynErgy solution.
b) Providing support for the installed system (e.g. configure/set up additional sensors actuators)

Synelixis is currently in the process of defining detailed pricing schemes, but a steady lookout on the market guides the company towards developing the optimal policy for SynErgy.

6.5 OVER

Before presenting the exploitation plan that OVER intends to take, it is important to explain how the company changed during the GAIA project. At the time of GAIA proposal, OVER was developing a new device in the field of GSM applications, the Cloudometer, which during the course of the project, for commercial reason, due to the nature of our business and depending on the opportunity OVER has met during these years, OVER has mainly focused on the use of the wired version, the NanOMeter EDS.

In these years, **OVER has become a leader in energy data management** for the Italy bank sector, having acquired important banks as customers such as UBI Banca (*https://www.ubibanca.com*), Monte dei Paschi di Siena (*https://www.mps.it*), Banco Desio (*https://www.bancodesio.it)*, Banca Popolare di Spoleto (*https://www.bpspoleto.it/it*) and Banca Nazionale del Lavoro (*https://bnl.it*)

Nowadays, OVER counts about **two thousand plants** and for 2019 there are new installations already planned, regarding additional hundreds of plants among bank branches and buildings. All of this led us to focus more, as anticipated above, on the wired solution respect to the wireless one, and to empower cloud platform responsible to gather and analyze data coming from devices deployed in the field (mainly bank branches but also, industrial and building facilities), in terms of functionalities and performance.

The GAIA outcomes perfectly suit this context. OVER, exploiting results of GAIA, will add new functionalities to the existing platform (named Overboard[22]) in order to provide existing customers with additional valuable information about their energy consumption profile. OVER will move in different directions: *(i)* **integration of the algorithms developed in GAIA**, within the last stable version of the OVER platform, *(ii)* **extension of the actual Sapienza infrastructure**, trying to add additional buildings to the set we already monitor in the GAIA platform and *(iii)* **exploitation of API within our educational network in**

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[22] Over the years, the names of the components of the Over platform changed and were rebranded wrt. those ones used in the proposal and DoW. Without entering into details, which are out of scope wrt. the objectives of this document, Overboard is the current name of (an evolution of) what in the proposal was the cloudmeter.

order to use GAIA API and increase interest and awareness of University students on the project and on the energy topics.

Platform Description

OVER will exploit GAIA results integrating the algorithms developed in GAIA, within the current version of the platform. This will lead OVER to a new version of the platform, which will be proposed to both its existing base customers and to new potential ones. In detail, OVER will add a new module in the platform allowing the user to perform cluster and anomaly detection operations, which will be named "**Profiling and Analytics module**".

Overboard is an Over-owned platform. It is an easy and accessible Building Management System (BMS) with which end users can analyze and manage all energy data coming from the installed sensors and actuators with the aim to detect wastes and decide energy saving policies to decrease energy costs.

Users have access to one or more facilities. The platform already provides this set of functionalities:

- An overview about what is happening on the set of plants in terms of Alerts, Historical Data and Key Performance Indicators (KPIs)
- An analysis view containing a set of information related to aggregated (per year/month/day and hour) energy data
- Maintenance functionalities providing real time connection to the energy plant with the possibility to implement, using the actuators installed and a proprietary rule engine, energy saving policies

At this initial set of modules, OVER will add a new one, containing what we have designed and implemented for the GAIA project. It will be responsible of these set of functionalities:

- Cluster of all the plant bound with a user. The platform allow user to cluster the accessible plant according to two separated features: *(i) energy consumptions* (seasonal and yearly averages) and *(ii) structure* (architectural features and schedules)
- Anomaly Detection and Prediction Module. It is responsible to determine whether a given measurement had to be considered an anomaly, considering exogenous factors such as temperature, luminosity or occupancy. The analysis will be performed at the end of each day and each time the algorithm is trained over all the available data up to the last 24 hours, excluding all the detected anomalies.

Position

The new version of the "Overboard" platform is perfectly suited to OVER's actual base customer, consisting of banks and industrial buildings. Its main customers have accounts with hundreds of buildings and the "Profiling and analytical module" perfectly respond to the need of clustering these facilities depending on some criteria or promptly detect energy anomaly to figure out which kind of actions implement on the field.

OVER also uses the new version of the platform for consolidating actual relations it has with Sapienza and for trying to acquire new buildings to add to existing infrastructure. All along the project, the pilots

installed in Sapienza demonstrated that energy savings are indeed feasible, and several meetings with the energy and building department of Sapienza were conducted over the years, in order to present results gathered from current installations and propose business plans to make investments for new installations in new buildings. In 2017 Sapienza announced the intention to have a 1M€ tender for equipping all the University buildings with infrastructures for energy monitoring similar to the ones offered by OVER and experimented in GAIA, and this surely a valuable outcome of the project. With respect to timing, according to the Italian laws, for tenders and contracts is quite complex and slow, therefore, at the time of this writing, the tender has not yet launched. The objective of OVER is to participate to such a tender and hopefully to acquire it. In such a fortunate situation, beside the buildings where it has already installed OVER devices (i.e., Palazzo Servizi Generali, Orthopaedics Building and the Department of Compute, Control and Management Engineering), OVER should be able to extend the actual infrastructure to the entire campus. The hope is that the tender will be launched in 2019, assigned in 2020 (this is the typical delay for such matters) and the implementation will be conducted in the years 2020 - 2022.

In the end, OVER also implemented, in the last workshop held at DIAG during "Seminar in Software Services" class three projects proposal exploiting GAIA infrastructure, using GAIA APIs and data coming from schools used in the projects. All the projects have been realized and OVER plans to repeat such activities in the forthcoming years. About 60 students have attended the workshop and some of them have actively contributed to work with the GAIA infrastructure through the realization of the project proposals.

Promotion

OVER will promote the new version of the platform among *(i)* its current customer base and *(ii)* its existing contacts looking for new potential customers.

Several activities, along with respective benefits, are planned as depicted in the following tables. Mainly, OVER will use online marketing, physical brochures and conference events. OVER imagines updating the website and Overboard platform with ad hoc information disclaimer explaining the benefits of the new functions offered. A proper acknowledgment to GAIA will be displayed under the information section of the "Overboard" platform. OVER plans to make new brochures better explaining the features, as well as create proper posts in social media, such as LinkedIn, and specialised App Blogs:

Table 10 OVER promotional activities

Method	Benefits
Online marketing	• Low cost • Inform and reach a wider audience (already existing customers and new potential ones) • Reach targeted audience (blogs)
Physical brochures	• Attract targeted users • Explain features with more detail

Conferences Events	● Stronger relationship, through physical contact, with the audience ● Explain features with more detail

OVER usually attends during the year to a set of conferences where it is invited to participate to tell its story or to contribute as expert in the energy sector. Just to make an example, during 2018 OVER participated to a workshop entitled "Italian Technology for SMART city" where we had a talk about energy efficiency technologies usable in smart cities.

OVER plans to exploit these kinds of events as opportunities to promote with a more level of detail, the new version of Overboard, describing it as part of the results obtained in the GAIA project, to a more specialized and focused audiences.

Financial Plan

The integration process has not started yet and in order to add the new module to the "Overboard" platform OVER needs to:

- Make compliant the current software module with the cloud architecture utilized by the OVER infrastructure.
- Implement an adaptable graphical user interface with the look and feel of the Overboard platform.
- Establish and evaluate the best solution to sell the additional module (including it in the standard version or offering it as a "plus" (as an advanced feature).
- Establish and evaluate the best price to sell the additional module.

6.6 Ellinogermaniki Agogi

Ellinogermaniki Agogi (EA) is a private school that invested both educational vision and effort in the GAIA project, aiming to make full use of its technical and educational outcomes in the years that will follow the period of the funded project.

The messages of the GAIA project for energy efficiency in school buildings and, through the school community in the wider society, as well as for experiential hands-on school-based learning practices contributing to this goal, are central to EA's overall philosophy. They also represent areas of particular interest for the families of EA's students, who entrust the school with the education of their children taking into account, among other things, its focus **on educational innovation and state-of-the-art education practices bringing real-life problems and humanity's global challenges and goals into the classroom.** During the whole project, the GAIA proposition has overall met a very positive response from students, parents, as well as EA's staff, due to its very topical and practical nature. The potential it offers for energy savings is naturally also a central point of interest for the school.

On this background, **EA will continue using the GAIA technologies**, and in particular the GAIA school building management system and the playful learning resource of GAIA Challenge, in order to engage its primary and secondary school students in learning activities on energy efficiency in the context of

environmental, STEM, and cross-curricular teaching and projects. The educational scenarios developed will thus remain in full use, while teachers will be updating and extending them to address the needs and circumstances arising in coming school years and additional curricular contexts engaged.

In addition, EA will build on its rich experiences and expertise to disseminate and exploit the outcomes of GAIA beyond its immediate school environment and community. The GAIA proposition and outcomes **will constitute new content for the teacher training** which EA has been successfully offering to several hundreds of teachers from across Europe and beyond in the context of international teacher professional development summer schools in the last ten years. This process has already started and the approach has been validated through the inclusion of GAIA as a case study in the **Play-Create-Learn Summer School[23]** in July 2018.

Further to that, EA is promoting GAIA as an "Accelerator" in the context of the **Open Schools for Open Societies** (OSOS) project[24] and its core network of one thousand schools in twelve countries. In this way, GAIA practices are being proposed to the educational communities of Europe as a basis for impactful school-based initiatives aiming to transform schools to innovative ecosystems and sites of science learning for which leaders, teachers, students and the local community share responsibility, over which they share authority, and from which they all benefit through the increase of their communities' science capital and the development of responsible citizenship.

6.7 SPARK Works ITC Ltd.

Product/ Solution Presentation

Spark Works' IoT platform is designed to **enable easy and fast implementation of applications that utilize an IoT infrastructure**. It offers extremely high scalability in terms of active users, number of interconnected device and volume of processed data, while remaining communication protocol-agnostic and able to operate on limited hardware resources. The platform accommodates real-time information processing collected from mobile sensors and smartphones and offers fast analytic services. The integrated modules if necessary partially depend on cloud infrastructure to offer **real time processing and analysis** of unlimited IoT data streams with **minimal delay and processing costs;** however, the platform is designed to ensure autonomous operability and native capability for data and information processing at an independent, local layer.
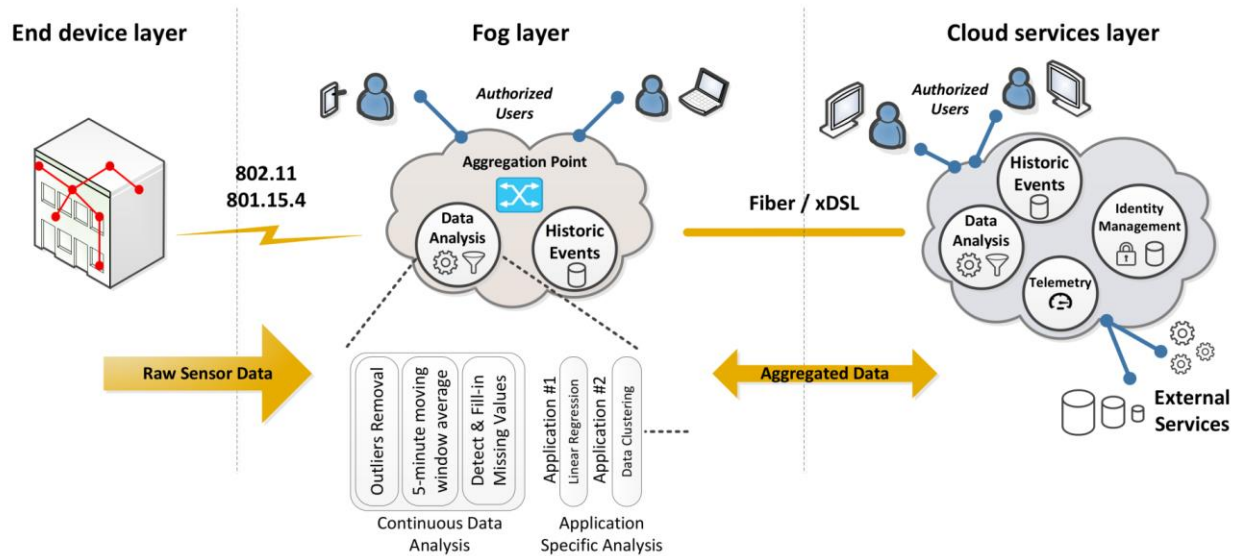
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[23] http://play-create-learn.ea.gr
[24] https://www.openschools.eu

Figure 9 High level architecture diagram

A high-level architecture diagram is shown in the figure above (for illustration purposes, the term "Edge" is interchanged with "Fog"). Designing an IoT infrastructure capable of being deployed at a national level, entails a broad range of functional and non-functional requirements. Such a platform will be used by a broad variety of people-centric applications, each with different roles and expectations from it. From a top-down architectural overview, the Spark Works IoT platform: (i) is completely containerized (currently Docker containers), allowing seamless horizontal scaling based on the data load; (ii) offers cutting edge scheduling capabilities by exploiting all features of Kubernetes and Swarm; (iii) operates in a fully decentralized manner; (iv) efficiently executes on-the-edge data analysis algorithms; (v) is deployed using an optimized microservices-based scheme; (vi) supports modern and agile software deployment, updating, patching and reconfiguration practices, commonly referred as CI/CD. Facilitated by the Continuous Computation Engine and enhanced by certain auxiliary modules which handle dedicated tasks while being deployed using the contemporary "Microservices" paradigm, the Spark Works IoT platform delivers a series of vital services, beneficial for every over-the-top IoT framework, installation or overall ecosystem: online analytics, storage & replay, end-to-end security and access management**.**

Novelty and Added Value: The SparkWorks IoT platform has been designed to be implemented in four different verticals, which would greatly benefit from our solution. In the *Healthcare industry*, the Spark Works IoT platform can be used to integrate wearable devices and smart home appliances with the cloud services used by healthcare centres. The platform uses real-time intelligence and allows a continuous analysis of collected sensor data, in order to identify emergency situations. Deployed in *smart buildings*, it can be used as a core enabling technology for collecting and analysing data from smart devices with a large number of specialized interconnected sensors being utilized for real-time energy consumption monitoring and data collection in the European building sector. On the *smart cities* vertical, the SparkWorks IoT platform can integrate traffic data, outdoor air-quality sensor data with urban management, ICT infrastructures for traffic planning and pollution management; sensors comprising an IoT infrastructure deployed at a large number of public and private buildings for a long period of time will generate, handle, transfer and store a tremendous amount of data, which cannot be processed in an

efficient manner using current platforms and techniques. On our last vertical, *smart transportation*, the SparkWorks IoT is capable of handling vehicle and driver-oriented sensor data through specialized algorithm integration. We integrated and properly expanded our solution into a holistic framework, which allows precise sensor orchestration, data acquisition, handling, manipulation and storage, paired with algorithm execution for advanced analytics and result extraction from all available information and datasets. SparkWorks has a fresh and different approach focusing on these four specific vertical areas offering customized services and solutions to the customers.

Market potential

According to MarketsandMarkets [23], the edge computing market will be worth $6.72 billion by 2022, up from an estimated $1.47bn in 2017. Key driving factors are the advent of the IoT and 5G networks, an increase in the number of 'intelligent' applications, and the growing load on cloud infrastructure. According to a European Commission study, the market value of the IoT in the EU is expected to exceed 1tn EUR in 2020. IoT connections are rapidly growing in Europe and are estimated to reach 1.8bn in 2020. This growth is based on the fast take-ups of IoT in several verticals, including smart metering, connected cars and government, among others.

The leading verticals for fog computing in 2022, in terms of market share, will be utilities, transportation, healthcare, industrial and agriculture. The healthcare & life sciences segment is estimated to cross USD 326 million by 2025, which can be attributed to provision of storage capabilities and real-time computing by edge computing solutions.

Marketing Plan

Positioning

Current state of the art faces the following challenges**:**

i.   **a severely fragmented market** - since all major players try to push their own proprietary, closed-source solutions, they face limitations in connectivity, interoperability issues and lack of vendor cooperation;

ii.   **the conventional centralized cloud computing is encountering severe challenges** - with the rapid development of mobile internet and IoT applications, conventional cloud computing is faced with high latency, low Spectral Efficiency, and non-adaptive machine type of communication.

The SparkWorks IoT Platform based on "Edge Computing" is a new architectural paradigm, which initiates a trend that shifts the function of centralized cloud computing to edge devices of the network. Edge computing entails processing and analysing data closer to the source of where that data is collected, being able to: **(i)** process this data, essentially becoming its own mini data centre and **(ii)** deliver this data to a nearby computing device, such as a gateway networking device, a computer, or micro data centre for analysis. With the SparkWorks IoT platform, a vast amount of processing power becomes decentralized from cloud service providers and **overcomes current limitations** of conventional centralized cloud computing by: **(i) increasing the speed of data analysis** and **(ii) decreasing the load placed on internet networks** to transmit huge amounts of data.

Table 11 Customized Smart Services for Facilities (e.g., buildings, houses, public utilities, farms)

Key Partnerships	Key Activities	Value Propositions	Customer Relationships	Customer Segments
Educational Community Urbanets project Partners from other projects	Software/Mobile App Development Frequent health checks for our architecture to make sure it remains robust with changing environments Hardware research based on needs of each building - installations Marketing and Promotion of our services	**Connect and integrate disparate systems and usage information into a central view** for better visibility into inefficiencies and issues gaining valuable insights, reducing operating costs. **Irrigation Monitoring and Control.** Save, optimize, plan and control the water use. **Reduce the energy and water consumption** of a facility (e.g., energy park, installation of solar panels in a field, pasture or desert parcel, farm) **Automated irrigation system**. Create an optimized water budget, irrigation schedule, or elevate your operation to the next level with an automated irrigation system.	B2B	Companies that provide services in water and power projects (e.g., irrigation water and energy park) Companies that provide services in public utilities BMS companies that want to enhance their product line and services
	Key Resources HW: Sensors & Meters (e.g. water, energy). Cloud Platform Data Security & Privacy		**Channels** Personal Selling Online/Website Google Play Store Blog & Social Media	

Cost Structure	Revenue Streams
Personnel Costs, Travel Costs, Equipment, Installation & other Costs	Amount of Contract Spark Work Services & apps (Free, Premium model)

SPARKS will not replace existing IoT platforms but rather fill-in the identified shortcomings and provide an interoperability platform and software development framework where all IoT solutions can be implemented and benefit from. Contrary to the current solutions, SPARKS will:

- allow bi-directional flow of information and management of IoT devices from the Big Data platform,
- boost code reusability in the form of data operators,
- allow current Big Data cloud deployments to exploit to the maximum the continuous heterogeneous hardware,
- break the barriers of existing deployments to exploit heterogeneity,
- enable the scalability of current and new Big Data deployments on heterogeneous resources in a transparent manner,
- enable software portability between cloud deployments,
- increase usability and maintainability as fewer "split source code" bases will have to be maintained,
- handle and analyse sensor data retrieved from thousands of sensors of different interconnecting devices simultaneously,
- resolve the incompatibilities and enable end-to-end remote monitoring and control and cloud enterprise integration,
- bring intelligence to the edge, speed up delivery, and increase the value of our services in the competitive market,
- offer robust security and privacy infrastructure featuring security protocols and privacy-preserving, mechanisms designed and developed to fulfil the end-users' requirements.

Promotion

In order to succeed in our different business sectors - healthcare, smart buildings, smart cities, transportation - SPARK will take part in specialized exhibitions and conferences related to its use-cases, increasing its brand awareness in the business market by establishing valuable connections, gathering new information, increasing sales, while also gathering valuable information and establishing mutually beneficial business relations.

Financial Planning

SPARKS will use a combination of business models to its customers based on their use cases, needs, and vertical markets:

1 **Licensing Agreement approach** - licensing intellectual property rights; we will use the right to develop an asset to third parties, under a fee (which can be linked to the units sold or flat);

2 **Software-as-a-Service** approach via a term-based subscription - business and individuals do not need to install applications on their own computers or own data centres; they can access the software using a Web browser or a mobile device and benefit from i) faster implementation timeframes, ii) access to products and information remotely, iii) no need for any initial setup costs (customers only need to subscribe and log into their account to get full access to the app and its updates), iv) access to the same software version for customers with same use-cases and needs. The SaaS approach means that we have a single version to maintain, upgrade, debug, and provide storage support for, the main revenue stream of the

6.8 Ovos media Gmbh

Ovos is targeting the educational market. Educational content is in a major period of transition from static content such as books towards online learning platform. The GAIA Project and its challenge is as we believe a reference project for an interactive, hands-on learning platform that engages students in an playful and meaningful way on this very important topic of energy saving. The numbers prove the concept of the challenge as appealing and interesting for students and teachers: almost **2.500 registered users** since the start of the challenge with an average session **time of approximately 15 minutes and a completion rate above 70% prove that the concept works.** The GAIA Challenge features a Content management system that makes it easy to add more languages and content modules.

Promotion:

Ovos is having talks and presentations on GAIA with important players in the Austrian Edutech and digital education market in Q1 and Q2 2019, such as the Future learning lab[25], LMS.at[26], KPH[27], MANZ[28] and Nakadake[29]. The goal is to bring the GAIA Challenge also to Austrian schools and find partners who are willing to add GAIA to the educational portfolio.

After a presentation of GAIA on January 22, 2019, **the Austrian ministry of Education proposed to integrate GAIA** on the EDUTHEK [31], the official online platform of the ministry of online learning resources in Austria. The Austrian Ministry is examining to provide a budget for a German-speaking Version of the GAIA-Challenge. Ovos will also reach out to potential partners beyond Austria such as Schulverlag[30], as well as partners in Germany.

ComnPlay Science:

The COMnPLAY SCIENCE (H2020, project number 787476) project aims to help Europe better understand the new ways in which non-formal and informal science learning is taking place through various coding, making, and play activities that young Europeans are nowadays increasingly engaged with. Ovos is part of the consortium and will contribute results and findings from GAIA in Practices (WP2) on informal science learning. Furthermore, Ovos shares the GAIA platform with the consortium partners engaged in science teaching and research.

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[25] https://futurelearning.at

[26] https://lms.at

[27] Teacher Education Krems, https://www.kphvie.ac.at/home.html

[28] http://www.manz.at/home.html

[29] http://www.nakadake.at

[30] https://www.schulverlag.ch

7. Conclusions

The GAIA consortium has developed an innovative set of components and an innovative methodology towards making the behaviour of people more energy efficient, with a focus on students and the educational community. The results of the piloting activities combined with the ones from the market survey consist the basis on which each partner has defined concrete exploitation plans to ensure the sustainability and further development of the GAIA components. In parallel, the GAIA partners have identified fields of synergies where they can cooperate to bring their solutions to the market. A summary of the roadmap of the planned GAIA partners' activities has been also provided in this document.

There are two important outcomes from this study:

a) The market surveys and the acceptance of GAIA solutions and approach during the pilots are both encouraging for further exploitation of the results. Namely, the market is continuously growing and interest in replicating the results is already witnessed.

b) In the GAIA consortium, commercial exploitation goes hand-by-hand with societal and scientific impact in terms of improved consciousness on the importance of energy efficiency for our society, of strengthened feeling in common responsibility and of fostered understanding that collaboration can bring multiplicative effects.

To sum up, the GAIA partners anticipate the expansion of their "business" capitalising on GAIA outcomes where "business" ranges from solution sales (e.g. SPARK, OVER) to improvement of the quality of educational services (e.g., for SK and EA).

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