IoT Meets Exhibition Areas: a Modular Architecture to Improve Proximity Interactions

(Article begins on next page)

IoT Meets Exhibition Areas: a Modular Architecture to Improve Proximity Interactions

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***Abstract*—The concept of proximity has been recently adopted in various fields of interest, with different meanings and implementations. In the Information Technology area, for example, proximity was used for analyzing user location and nearness to objects/people, and has already changed the way people interact with each other and with technology itself. In this field, the concept is becoming more important with the diffusion of IoT, the network of "things" connected to each other to share services and features. This paper aims at analyzing how the IoT can improve proximity interactions by developing a case study in an exhibition area (tradeshow), with the goal of enhancing participants' and exhibitors' experience. Starting from the analysis of existing works, we designed a scenario to identify IoT-enabled application features for both participants and exhibitors. We propose a modular architecture able to provide different services to all stakeholders: it offers a baseline for exhibitors who want to provide new interactive services to participants (e.g., to control some exhibited device) and some social services to participants for interacting among themselves and with exhibitors. Finally, we validate our architecture implementing the initial scenario on top of the AllJoyn™ framework, an emerging proximity based software framework.**

I. Introduction

The last century has seen the design and the introduction of new devices and tools that, aiming only at improving the lives of people, have completely changed their habits. Moreover, in the last five years these devices have contributed to the diffusion of the concept of Internet of Things (IoT) that is gradually acquiring an important role in the spread of new useful services in our society. As the name suggests, the IoT is the network of physical objects that are supposed to be always connected to the Internet with the aim of sharing services and information with other connected "things". Smart fridges, intelligent bulbs or simple interactive tables are examples of what is already considered part of the IoT network and inspire the development of new innovative devices. Furthermore, the spread of new services related to these innovative objects and devices is increasingly growing thanks to the diffusion of sensors. Many different sensor types can be found, but the one that has significantly encouraged the spread of IoT devices is the "proximity sensors" group. The "proximity" term refers to the concept of *nearness* applied to things: it can be defined as the knowledge of objects, people, or places near the considered thing enhanced with additional information about the distance. Thanks to the combination of proximity, IoT devices and sensors, new user-centered customized services are emerging in various fields of interest. An example of the application of this combination is the virtual heritage: proximity sensors, IoT devices and user-centered interfaces are starting to improve the experience of museum visitors introducing new interactive services (e.g., 3D visualization of lost details related to near objects) and are increasingly attracting the interest of communities and institutions. This paper focuses on another area of interest: exhibition areas like tradeshows, a specific domain in which IoT has not yet been used in combination to proximity, with the goal of enhancing both the exhibitors and visitors experience. For the purpose of this paper exhibition areas are events in which companies, institutions, or associations show their activities and products to participants that are interested in their work. Since a few years ago, the tradeshows were boring meeting in which companies showed their products and gave company activity information to participants through brochures and posters. Nevertheless, in the last years, IoT is adding new technological services enhancing the whole tradeshow experience: new mobile apps have already been developed to provide features such as list of exhibitors, map of the fair and calendar with scheduled events. This paper aims at identifying new additional proximity services not yet considered in the literature with the purpose of improving the experience of all stakeholders involved in a tradeshow: organizers, exhibitors, and participants.

The remainder of the paper is organized as follows: Section 2 analyzes motivations and existing related works, Section 3 reports a scenario used to identify requirements and needs, Section 4 describes the modular proposed architecture and Section 5 describes the technical validation of the architecture. Finally, Section 6 concludes the paper with some considerations and future works.

II. Background

Location Based Services (LBS) are usually defined as a general class of software services that use location information to provide and control different useful features. They are currently used in many different contexts providing always new and useful facilities: Gao et al. [1], for instance, show how much accuracy is achievable through the use of LBS for location-based access control; Aloudat et al. [2], instead, discuss about the possibility of using LBS for sophisticated location-based emergency services in Australia.

However, with the expansion of the smartphone and tablet markets, a special class of LBS is emerging in an interesting way: Proximity Based Services (PBS), that are specialized services whose specificity depends on the relative distance between a user and other (possibly moving) entities, according to the definition given by Mascetti et al. [3], irrespective of their absolute position or location.

Even though it is not so easy to separate proximity-based applications or projects from location-based ones, PBS have been already used for different projects and in several different areas of interest. Susperregui et al. [4] show how PBS is used in art exhibition areas (e.g., museums): their proposed prototype enables supporting visitors with interactive services, such as personalization of the content due to user preferences. Instead, Bose et al. [5] present a method for smart meeting based on users proximity. It uses personal information to accurately suggest people to meet up in close proximity to the user and suggests activities to be done with them. Furthermore, Papandrea et al. [6] and Parra et al. [7] present two different prototypes for the transmission of marketing information to end-users based on their proximity-acquired location and profile.

Nonetheless, our interest was related, specifically, to an area in which proximity has not yet exhaustively explored: the Internet of Things (IoT). Guo et al. [8] define IoT as the emerging trend of augmenting physical objects and devices with sensing, computing, and communication capabilities, connecting them to form a network and making use of the collective effect of the networked objects. Thus, we can think to IoT as a network of independent “things”: people, data, and devices are considered as indistinguishable in the meaning of independent things that interact with each other and with the surrounding environment in order to share and provide services and facilities.

Chianese et al. [9] present an IoT architecture that is able to support the design of a smart museum, an ordinary cultural space that becomes intelligent thanks to the definition of an innovative model of sensors and services. The authors conduct the study considering both the interactions among visitors and between visitors and environment/objects. The main difference with our proposal is that their work applies to the cultural domain, that has specific requirements different from the commercial domain in which tradeshow can be placed.

In order to enable proximity sensors technology various frameworks have been developed. Two different framework solutions were found for our needs: the AllJoyn™ framework [10] and Crossroads [11]. Crossroads is described as a framework for developing proximity-based social interactions, but no freely available information and code were found at the time of the research; whereas, the AllJoyn™ framework is supported by detailed documentation and provide free, open-source library. Moreover, Wang et al. [12] demonstrate that the use of a practical and easy-to-use proximity service framework that supports multiple platforms and languages, like the AllJoyn™ framework, can enable the development of distributed proximity application.

Finally, different methods to establish relative position in indoor environment to support proximity exist. Ortakci et al. [13] show how RFID technology can be used to establish 3D position of an object; instead, Naya et al. [14] show how Bluetooth devices attached to people and objects can be used to estimate room-level proximity and mutual proximity between them. Moreover, Namiot et al. [15] demonstrate that Wi-Fi hot spots can be used as presence sensors that can trigger access for some user-generated information snippets.

III. Scenario

In order to identify the most significant improvements possibly given by the combined use of IoT networks and proximity-based interactions in a tradeshow, the following scenario was designed.

In this analysis it is assumed that an exhibition, like CES[1], has already been organized and an application for the specific event was developed for every mobile operating system. In addition to usual exhibition applications that typically provide a map, an exhibitors list, scheduled events, and other common features, this app provides new proximity services that can be divided into 3 different categories, detailed below.

1) *Services for user-products interaction*: they allow nearby participants to try and experiment products and devices showcased in a stand present in the tradeshow. They include: *a*) interaction (e.g., viewing or controlling) with products provided within each exhibitor's proximity area; *b*) management of a waiting list for product interaction.
2) *Services for user-exhibitors interaction*: they let participants get in touch with exhibitors. They include: *a*) contacts and information exchange within exhibitor proximity area; *b*) management of a waiting list for talking with exhibitor staff; *c*) chance of booking a meeting with exhibitor staff members.
3) *Services for user-to-user interaction*: they enable users to establish new relationships according to participants skills and work opportunities offered by their company. They include contacts and information exchange among participants present in the same exhibitor proximity area (e.g., a participant could also be a recruiter for a company that is looking for new employees).

Fig. 1: Scenario

Figure 1 shows a rendering of a simple instance of the scenario we designed: there are 4 different exhibitors offering different services. They can be divided into two different groups, depending on the approach they choose to participate to the tradeshow.

The first group of exhibitors (A1, A2, and A3) decides to use the interactive proximity system offered by exhibition organizers, so all of them provide social services and interaction with their products. **Exhibitor A1** is a robotic company that decides to participate to the fair to show her

[1]The International CES is a global consumer electronics and consumer technology tradeshow that takes place every January in Las Vegas, Nevada

car robot project. Even though it is a new project and it is at his initial phase, the company decides to let users interact with her remote controlled robot car used for research experiments. The participants are, consequently, able to control robot movements for 30 seconds. **Exhibitor A2** is a manufacturer of indoor monitoring sensors that decides to show her products able to track temperature and humidity of an ambient. The possible user interactions are two: current acquired values are shown on a monitor; moreover, participants can see interactive charts showing historical detected values on the mobile app. **Exhibitor A3** is a weather station manufacturer that shows her next generation weather stations able to track the outside and inside air quality. They get information about temperature, humidity, pressure, noise and CO_2 concentration. The current values are shown on a monitor and participants can navigate charts reported on the app showing historical data acquired by shown products.

On the other hand, one exhibitor belongs to the second group because it decides not to use the interactive system: **Exhibitor B1** is a company that produces motorized shades. Even though its shades can be controlled through a mobile app, the company decides to use only the traditional paper brochures to show its products functionalities and its current research activities.

Consequently, starting from the description of the just shown tradeshow structure, we describe what would happen in a typical day in a fair.

We focus our attention on 3 participants: Aldo, Bianca and Cesare.

Aldo enters the exhibition at 9 o'clock, buys a ticket and sees the QR code that is shown on the wall just in front of the entrance. He scans it through his smartphone and downloads the interactive app provided by the organizers. After installation, Aldo opens the app and types in the required information: at the first startup the app asks information about his identity, social contacts, e-mail and so on. Thus, he presses the "Start the visit" button and, putting the smartphone in his pocket, actually starts the visit.

Bianca arrives at the tradeshow at 10 o'clock. The evening before, she downloaded the app and she inserted all the required information. So, at her entrance, she takes her tablet, opens the app, presses the "Start the visit" button and puts the tablet in her handbag starting the visit.

Cesare, on the contrary, arrives at 10:15 and immediately starts the visit as a "traditional" visitor deciding not to use the provided app.

While Aldo is walking among the stands, his phone rings because he has just entered the area covered by the first stand and, as soon as he takes the smartphone from his pocket, he finds a notification saying that he is near the "Exhibitor A1" stand. Once opened, the app shows him all the company information and notifies the possibility to interact with its product: a robot car. Thus, Aldo goes near the robot and a button appears on his app: "Take control of the robot". So, he accepts to interact with it and, considering that no other people are in the queue, he starts to control the robot through the dashboard shown on his smartphone. After 30 seconds, the app notifies him that the time was expired and shows a button to try again (no one was added to the queue in the meantime). He presses the button and plays with the robot for other 30 seconds. At the end, he walks away from the stand and the "Exhibitor A1" app module disappears.

As soon as Bianca arrives, she approaches the "Exhibitor A1" stand, too, but this time there are 20 other people in the queue, so the app shows the queue length. She presses the button to book the trial and the system register the request notifying her position in the queue (established when she approaches the stand area). The app also informs her that she would lose her priority by exiting the "Exhibitor A1" covered area. As she is interested in the product and she wants to become a retailer, she decides to wait in the area, and meanwhile to try to speak with one of the exhibitor staff members. However, all of them are busy, so the system shows her a details page with information about the two available employers: Luca, an expert of the technological area, and Giacomo, a commercial expert. Thus, she thinks the right person to speak to is Giacomo and she books a meeting with him.

Therefore, Giacomo receives a notification on the company tablet placed on the desk and, as soon as he ends his meeting with the previous person, he goes toward Bianca. During the meeting they exchange their LinkedIn accounts and at the end Bianca looks again at the robot interaction queue: there are still too many people before her, so she exits the "Exhibitor A1" area planning to come back later.

Simultaneously, Cesare has already collected a lot of paper brochures and he passes near the "Exhibitor A2" stand. Interested in the shown products, he decides to talk with one of the exhibitor staff and he approaches Maria, a staff member. She tries to get information about him in order to offer the most important information about the company, but he is not using the app so she can only give him another brochure.

In the meanwhile, Bianca is continuing her visit and she goes to the "Exhibitor A3" stand and, considering that she is really interested in the company activities, she first looks at the information shown on the monitor. Then she downloads all the company information on her tablet and she books a meeting with one of the staff members. During her waiting time, she examines historical data detected and stored by the available products through interactive charts shown in the app. After the meeting she goes on with the visit.

Afterwards, Aldo comes near the "Exhibitor B1" stand. It is a simple "traditional" stand without any app interaction, consequently he looks briefly at the shown information and he goes further.

Towards the end of her visit, Bianca comes back to the "Exhibitor A1" stand because she wants to try to control the robot car. This time the queue is empty, so she plays with the robot as soon as she arrives.

Later on, Aldo comes back to the "Exhibitor A1" stand, too, because he enjoyed so much the play and he wants to try it again, but he finds Bianca currently playing, therefore, he decides to wait. To occupy the spare time he decides to read the public information about nearby participants and, as a surprise, he discovers that Bianca is an automation representative for her own company. She usually organizes meetings between robotics industries and companies that want to use robots in their production line. In the information of her company Aldo discovers that they are looking for new employees, so he sends immediately his LinkedIn contact to her, and he approaches her asking to speak as soon as she finishes to play with the robot. At the end of Bianca trial, Aldo asks her for company information and available work positions suitable for him: Bianca received his contacts on her tablet, so she can give him only the most interesting information. Then, at the end of the meeting Bianca's phone rings and she runs away.

Finally, Aldo and Cesare exit the exhibition.

IV. Architecture Design

Starting from the scenario, a modular logic architecture was designed with the aim of providing an improved experience to all the stakeholders involved in a tradeshow.

As described at the beginning of the scenario, different services for each different exhibition stakeholder had to be provided and so different requirements had to be pursued. Thus, the architecture was designed as a flexible modular solution able to provide different levels of services to each tradeshow stakeholder: organizers, exhibitors, and participants.

The main requirement of the system is related to the proximity concept: every time a participant approaches a stand she may acquire new services depending on what each exhibitor shares. Moreover, every exhibitor may want to acquire information about participants that are visiting its exhibition area and participants may want to interact with other participants within the same stand. Furthermore, some services can be shared among different stands. Consequently, the tradeshow can be modeled as a group of different stands that need to use and provide facilities to participants, optionally using shared services (e.g., cloud storage used to provide historical information acquired by shown products).

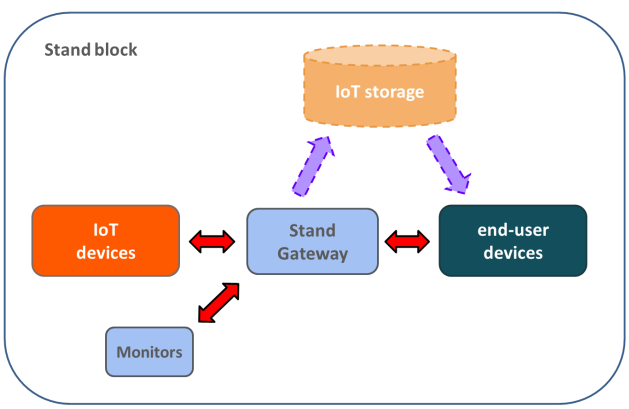

Fig. 2: Architecture design

Figure 2 shows the designed logical architecture: it is a modular system replicated for each stand that we will call "*stand block*" from now on. In the "*stand block*" the following components can be found.

The **IoT devices** represent the products that the exhibitors may want to provide to the participants for a trial. The information exchanged with this component (e.g., data format, communication protocol) depends, obviously, on each specific *IoT device*. Moreover, each device works only within its exhibitor's stand to provide services for visitors that are in the dedicated stand area. Thus, the **IoT devices** was designed as an independent block that communicates with the *Stand Gateway* (that acts as a delivery and "translation" center). In the sample scenario we have, for example, a robot, a weather station, and an indoor monitoring station.

The **End-user devices** (e.g., smartphones and tablets) represent the devices on which the tradeshow app will be installed. This app will let participants interact with products, exhibitors and with each other. Considering that every exhibitor will probably provide different IoT devices with different available functions, the app interface may be extended by each exhibitor. So the app was designed as a modular application able to integrate different customized modules.

The **IoT Storage** component is responsible for the storage of historical data coming from *IoT devices*. It is an optional module that each exhibitor can decide whether to use. Moreover, in each tradeshow organizers can decide whether to provide an exhibition common storage or to demand the storage implementation to each exhibitor.

The **Stand Gateway** is a central device that enables the communication between all the other architectural components and provides support to each stand for shared services (e.g., product interaction waiting list). It can be considered as a dispatcher and a "translator": the *IoT devices* send information to the *Stand Gateway* using their own format for the data or their own protocol to communicate. So, considering that data coming from *IoT devices* changes according to each product, the *Stand Gateway* has to be extended by each exhibitor to support the specific *IoT devices* that she wants to show to participants. Moreover, it may include the possibility of connecting one or more monitors to show additional information.

The **Monitors** represent common displays connected to the *Stand Gateway* to show a simple slide show or dynamic content related to each exhibitor.

Before the analysis of details about the most complex modules, let's identify the role of each stakeholder in the components customization process. The described elements can be divided into 3 different overlapping groups depending on the customization required by each stakeholder:

- The *organizer components* group includes all the elements that will be provided and/or extended by organizers. It contains the *Stand Gateway* and the *Monitors* that the organizers will supply for the tradeshow. Moreover, it includes the *IoT storage*, that may be provided by the organizers and the *End-user devices* app, too, that the organizers have to extend (i.e., the app that will be installed on *End-user devices*) by inserting exhibition details and exhibitors information.
- The *exhibitor components* group includes the elements that will be provided and/or extended by exhibitors. It contains both *IoT devices*, directly supplied by each exhibitor and the software running on *Stand Gateway* that needs to be customized by the exhibitors that want to provide interaction with their products. Furthermore, the *Stand Gateway* can be modified to use a non-common

storage: a storage different from the one provided by the organizers. In addition, the *End-user devices* app is included, too, because each exhibitor has to extend it to integrate its own interaction module.
- The *End-user components* group includes only the *End-user devices* owned by each participants. The participants will insert their own personal information at the first startup of the app.

The following subsections show the details of the most complex architectural elements.

A. End-user devices

This block represents user devices (e.g., smartphones, tablets) that will execute the exhibition app developed for the specific tradeshow. As already said, the app is a modular application modified/created by the exhibition organizers, and then extended by each exhibitor to integrate their own interaction module.

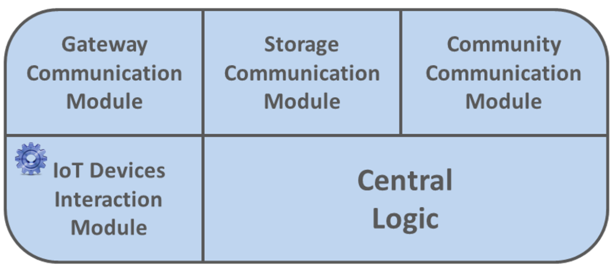

Fig. 3: End-user devices app internal blocks

Figure 3 shows the app logic architecture involved in the *End-user devices* block. We can distinguish "standard" elements, that neither the organizers nor the exhibitors have to modify, and a "non-standard" element (marked by a gear) that needs to be extended by exhibitors in order to provide customized services.

The **Central Logic** is responsible for different essential services. It collects and stores user personal information, manages user authentication and updates personal data every time a user changes them. Furthermore, it is responsible for storing and showing exhibition information inserted by the tradeshow organizers. Moreover, it manages proximity detection (providing required information to the *Community Communication Module*) and coordinates all the other *End-user devices* app internal blocks.

The **IoT Devices Interaction Module** is the manager of all exhibitor-specific extended interfaces: each exhibitor will extend the app with its own module to integrate its own *IoT devices* for trials. This is the only "non-standard" component that acts as the container and the controller of all these extensions. Furthermore, it is responsible for the user interface of booking requests sent by participants that want to take part to product trials, that are sent to the Gateway (through the *Gateway Communication Module*) that processes them.

The **Gateway Communication Module** manages the communication with the *Stand Gateway* acting as a distribution center that receives and sends data from and to the *Stand Gateway*. It supports the *Central Logic* in the proximity detection process supplying the proximity information received from the *Stand Gateway*. Moreover, all other *End-user devices* app internal components communicate with the *Stand Gateway* through this element. In fact, the interactive interfaces provided by the *IoT Devices Interaction Module* sends requests and receives answers to/from the *Stand Gateway* through this module. And the information acquired by the *Community Communication Module* are sent to the *Stand Gateway* using this component, too. This element is "standard": a common layer supports all the communications with the *Stand Gateway*, so this component doesn't need extensions.

The **Storage Communication Module** is responsible for the communications with the *IoT storage*.

Eventually, the **Community Communication Module** is responsible for all the services needed to discover other participants and to interact with both exhibitors and participants. The acquired information (e.g., nearness to other participants) are sent to the *Stand Gateway* for computation and sharing. Moreover, this module is responsible for contacts exchange among participants.

B. Stand Gateway

It is a device that manages the communication between all the other architectural components providing different kinds of services.

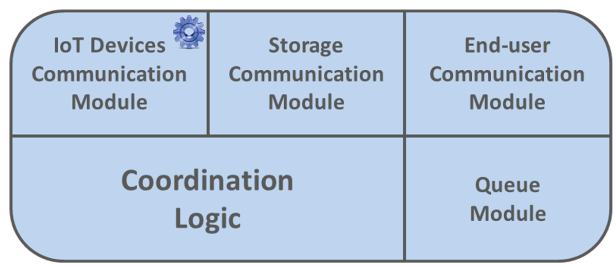

Fig. 4: Stand Gateway internal blocks

Figure 4 shows all the internal logic modules composing the *Stand Gateway* block. Most of them are "standard", meaning that neither the organizers nor the exhibitors have to modify them, instead the *IoT Devices Communication Module* needs to be extended and customized by exhibitors.

The **Coordination Logic** coordinates the communications and the interactions among the other *Stand Gateway* internal blocks. Moreover, it supports the *End-user devices* in the proximity detection process: it receives proximity information related to nearby participants, exhibitors and exhibition area from the *End-user Communication Module*, computes it and then shares all acquired data with all nearby *End-user devices* (using the *End-user Communication Module* for the communication).

The **End-user Communication Module** exchanges information with *End-user devices* providing requested information and computing received one. Through the *Coordination Logic*, it delivers received data to the right *Stand Gateway* internal block and sends the computed answers to the *End-user devices*.

The **Storage Communication Module** is responsible for all the communications with the *IoT storage*. It provides all methods and services useful to store and/or get historical data related to shown *IoT devices*.

The **IoT Devices Communication Module** provides communication with the *IoT devices*, so it is a "non-standard" element and needs to be extended by each exhibitor in order to be adapted to all the available devices.

The **Queue Module** is responsible for both the products interaction queue and the exhibition staff member meetings queue. It stores an ordered list of all the users that enter the specific exhibition area defining a queue for products interaction. Moreover, it stores every request for staff member meeting creating another ordered list for each exhibition staff member.

V. Validation Through Scenario Implementation

In order to validate the designed scenario, a working prototype has been implemented, according to the described architecture. As discussed in the Architecture Design section, each architectural element is used and needs different changes by different fair stakeholder, so the prototype implementation can be divided into 3 different steps:

- Implementation of a *base system*, accomplishing baseline functionalities (e.g., waiting list, social interaction among participants) that are always valid and don't require any change neither by organizers nor by exhibitors.
- Implementation of *organizer components*, i.e., elements accomplishing additional services (e.g., IoT storage) that need to be modified by the organizers.
- Implementation of *exhibitor components*, i.e., elements accomplishing additional services (e.g., products interaction) that need to be customized by the exhibitors.

For the *base system*, the first deployment choice was related to an IoT proximity framework, a universal and reusable software environment that provides particular proximity functionalities to facilitate development of software applications, products and solutions.

As already discussed in Section 2, two different proximity frameworks were found: Crossroads and AllJoyn™. As supported by Wang et al. [12] and considering that no freely available information and code about the Crossroads framework was found, the AllJoyn™ framework was chosen. However, this choice is not restrictive: the architecture is flexible and can be used with or without a framework or with other solutions.

The AllJoyn™ framework enables devices and apps to advertise and discover each other. It provides two different software distributions: a *Standard* version, thought for non-embedded devices, like Android, iOS, Linux and a *Thin* version, thought for resource-constrained embedded devices, like Arduino [16] or Linux with limited memory. In our case, only the standard version was used: to implement the stand gateway on a Raspberry Pi and to develop the basic version of the mobile application for the specific event. For the sake of the prototype only Android devices were used, but AllJoyn™ supports most of existing mobile operating systems.

Different techniques and radio technologies can be used to establish the relative position of end-user devices, but we decided to use the Wi-Fi based positioning, because, as declared by Namiot et al. [15], it is one of the most used approaches to indoor location. Moreover, the used AllJoyn™ version did not support Bluetooth technology for proximity detection.

Consequently, the AllJoyn framework was used to implement the stand gateway (on the Raspberry Pi) and the mobile app (for Android devices). Each of them provides different services, so the framework was customized to provide all the essential services listed below.

The **Stand Gateway** provides services such as staff meeting queue management and monitor connection used to show exhibitor information on connected displays, whereas the **Mobile Application** provides the common services already discussed in the previous section (e.g., insert personal information into the app, book a meeting with exhibitor staff).

The following two customizations regard the effort that organizers and exhibitors should accomplish to customize the architecture for their specific tradeshow.

In order to perform the *organizer components* implementation, the gateway and the app were extended to support the following organizers requirements.

To customize the system for a specific tradeshow, an organizer should only do the following actions:

- Insert information about the tradeshow into the app.
- Update the gateway inserting information about all the exhibitors.
- Optionally choose an *IoT storage*.
- Optionally extend the gateway in order to provide methods to use the *IoT storage*.

Whereas, an exhibitor that wants to provide additional services to participants using the proposed architecture, should accomplish the following actions:

- Extend the gateway in order to implement the actual products interaction.
- Create its own software module that will be shown into the participant app to let them enjoy product interaction.
- If necessary, extend the gateway in order to store historical information on the cloud storage.
- If necessary, extend the gateway in order to show custom information on the monitor.

Consequently, in order to validate the architecture some implementation choices were made.

For this specific prototype, the ThingSpeak cloud service [17] was chosen as the tradeshow shared *IoT Storage* because of its available API and well-done documentation.

Figure 5 and Figure 6 show two different prototype implementations of stand blocks: a netatmo [18] weather station and a robot car (used in internal research projects by the Telecom Italia SWARM Joint Open Lab) were chosen as *IoT devices* for this technical validation. In addition, a sample mobile application was developed. As shown in Figure 7, the app provides:

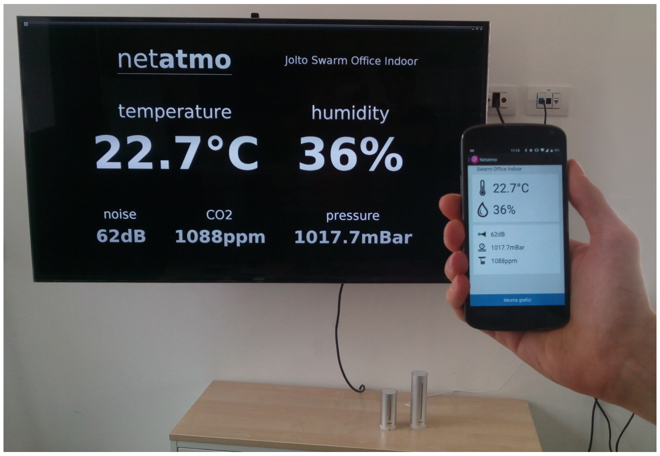

Fig. 5: Prototype Screenshot: netatmo weather station

Fig. 6: Prototype Screenshot: robot car used in internal research projects by the Telecom Italia SWARM Joint Open Lab

- the list of all available stands; each section is accessible only within the specific stand area and shows the company information and the optional buttons needed to interact with available products;
- a section that shows the available participants within the specific exhibition area;
- two sections that show saved contacts and saved exhibitors;
- a section that shows personal information with the possibility to update it.

All the experiments were conducted in a small area with 3 different *Stand Gateways* that run at the same time and 4 people were involved as simulated participants of the tradeshow.

In order to establish whether a participant was in an exhibitor area or in another, the strength variation of Wi-Fi signal was used: considering that there was a minimum distance of 3 meters among each gateway, the system establishes the nearest exhibitor area depending on the strength of the signal.

The experiment demonstrates that the designed architecture is actually flexible and feasible, in fact it improves exhibition experience by adding new proximity services (e.g., historical charts related to indoor monitoring sensors were shown only to user within the exhibition area and robot car interaction was possible only after a waiting time depending on people that had entered the same area before) and promotes the distribution of work among each stakeholder.

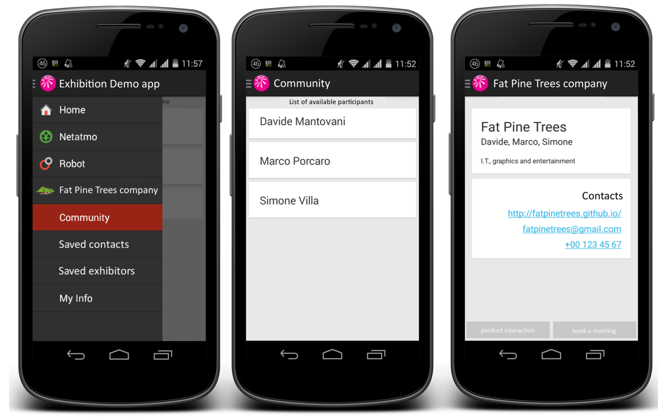

Fig. 7: App Screenshots

VI. Conclusions

In this paper, we present a modular architecture that improves the experience of all stakeholders of a tradeshow. The system requirements stem directly from a simple scenario that identifies the role and the desirable services of and for both exhibitors and participants. The proposed modular architecture considers different services needed by each involved stakeholder (organizers, exhibitors, and participants).

The system has been prototyped and a preliminary validation has been performed, for verifying its technical feasibility.

Future work will include a validation of the system through a user study: some public sessions will be organized to validate the architecture from each stakeholder point of view. The system will be evaluated by a adequate number of people involved as different stakeholders of the tradeshow aiming at obtaining structured information about benefits and improvements actually felt by both exhibitors and participants.

Acknowledgment

The authors wish to thank the MSc students Davide Mantovani, Marco Porcaro and Simone Villa for developing the architecture and implementing the scenario. Teodoro Montanaro currently exploits a research grant by Telecom Italia SWARM Joint Open Lab.

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