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A new vision over Agile Project Management in the Internet of Things era

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Abstract

Living in the modern society, where the *Internet of Things* (*IoT*) network is constantly evolving and *Things* belonging to the network are expanding new functions in a fast pace, there is inevitably a need of having a new vision over the software project management that should keep up the pace with these changes. The impact of the new smart devices is major and can be seen at all levels of software project management. By creating a project management solution across the *IoT* network, we aim to improve the efficiency and to optimize parameters such as: teamwork, analysis of a large amount of data, project managers and stakeholders input, resource planning, project development and feedback speed. A great contribution in achieving optimization and efficiency improvement for the software project management solution have all the smart devices using high computing power, high data transmission speed and efficient data processing. Therefore, this paper proposes an *Agile* project management solution that adapts to the *IoT* network, embedding Things with their features correspondingly into the project management process. Putting the project management process across the *IoT* network, the *Agile* project management solution slightly changes the steps of software project management as to increase different project parameters as like: team collaboration, team efficiency, project technique level, project technological level, project automation level.

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Keywords: Internet of Things; Agile; SCRUM, Sprint, smart device; software project management;

1. Introduction

It can be easily noted that nowadays any company or individual that develops a product or provides services to an end user usually follows a pre-defined plan with exact steps to follow as for the product/service to reach out to the end user as planned from the beginning. There is a project plan created for almost every product/service we can buy from the market, and behind the final product/service there are groups of tens or even thousands of people that have worked all together in realizing the product/service as we see it.

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As the process of making a product or providing a service is very complex, there is a need in creating a project management plan that begins from the idea of providing that product/service to the end user and can never end as it usually includes the maintenance of the product/service for as long as the user uses it.

In particular, the software industry follows the same rules when referring to the process of creating a software that is to be delivered to a certain end user, individual or company. So, we can define the term called software project management (SPM) as being the process that starts from the idea of creating a software continues with developing the software itself and maintains the software for the end user during the whole lifecycle of the software. In detail a SPM defines a plan with steps needed for the software to be delivered in terms of defining the software specifications, creating tasks for developing the software, plan the actual tasks to the allocated resources, maintaining the software by getting constantly feedback and improving the software as for what the end user expects to have as a final product.

A software project management plan can be defined as being as a process composed of six steps:

1. *Brainstorming for an idea*: This is the first step where the idea of the software is elaborated and where the investigations take place for finding out if the idea can be implemented and what are the pro arguments in implementing the idea. The most important role in deciding if the project can go on has the project manager at this phase. The main goal of this step is to determine if the software is feasible for the team to implement (Baars, 2006).
2. *Creating specifications*: The second step represents the phase where all the requirements must be completed. This involves the identification of all the expectations, analysis of all possible solutions for implementing the idea from the first step and defining the limitations if any found during the process of selecting the proper solution for implementing the idea (Baars, 2006).
3. *Defining the software architecture*: This third step requires a run through all the requirements noted at the second step and use them to create schemas, UML diagrams, architecture prototypes, flow charts that will represent the basis for the final software architecture that will be defined. On this step, there can be multiple schemas, diagrams or flow charts created so for the team to have different point of views when designing the final architecture. The final decision over the architecture is taken by the project manager after consulting the architects and the team leader responsible for designing the architecture.
4. *Developing an implementation strategy based on specifications and architecture*: At this point in the SPM there can be asked for the help of contractors or even developers in order to supply the project with every resource needed for being able to start the implementation. All 3rd party tools needed for the implementation are bought/downloaded (for open source ones) installed and set to be ready for use in the implementation phase (Baars, 2006).
5. *Implementing the actual software*: This phase of the SPM is dedicated mostly to the work of the developers. Even so there is no pause in the SPM process for the other project categories involved. The designers must monitor that the implementation respects the design created in step 3, the contractors must sustain a live feedback between them and the developers to fulfil all the necessary changes if needed during this phase, and nonetheless the project manager who is responsible to coordinate the project and all the resources allocated to it to obtain the desired software for the end user. At this stage, the project manager can reorganise the teams, the resources, the plans, the diagrams accordingly to the implementation phase in case the implementation implies changes to these project entities. Also at this point in the SPM there shouldn't be made changes to the list of requirements only if the final customers require them and if it has this defined in the initial agreements with the company developing the software (Baars, 2006).
6. *Maintaining the final product*: This last step of the SPM might be looked over by an external party as a being a small and "can be excluded" step from the SPM. Though by looking to the newest researches over the software project management domain this is most cases the highest important step as it effectively translates the software from a proof of concept to a reliable, feasible software ready to compete on the software market. This is due to the fact that the main purpose for almost all the software products nowadays is to get out live as soon as possible, using in fact the feedback from the company as a real live testing system for their software. Of course, this is highly not recommended but it's an accepted approach as end users are getting more and more used to updating and accommodating to the newly features of a software. At this step, there are also accepted small changes to the requirements if

this is highly necessary as the purpose of creating a software is not to impose an idea to a client but to create a model for our idea over the customer's requirements (Baars, 2006).

2. Presentation of concepts

2.1. Agile Project Management

Agile Project Management (APM), which is commonly known as *Agile* refers to an iterative method for managing, designing and developing activities in the software industry mainly in engineering, information technology and other businesses that provide new products or services developed in an interactive manner. The *Agile* approach in very useful, helping teams in overpassing or even excluding unpredictable behavior in the project management process by using a management model based on iterative work and heuristic feedback.

SCRUM is the best way of introducing *Agile* approach on project management as it's simple and easy to handle by the whole team involved in the project. SCRUM represents in fact a management framework for incremental product development using one or more cross-functional, self-organizing teams of about seven people each (James & Walter). It uses heuristic feedback, team self-management, and aims to build properly tested product increments within short iterations. The short iterations are called Sprints and they have a fixed length not exceeding 30 days, but usually kept as short as possible. The idea of a Sprint is for the teams to try to build a releasable product increment at the end of the Sprint (James & Walter). Another important part of SCRUM is that it uses only three roles in managing the software. These roles are: *Product Owner*, *Scrum Master* and *Development Team*.

- *Product Owner*:
  - It has a leadership role.
  - It is responsible for creating and assuming the requirements by approving the final version.
  - It constantly re-organizes the *Product Backlog* to adjust the software to the demands of the clients taking in consideration heuristic feedback.
  - It can take the decision over the release date and agreements or in the process of continuing the development.
  - It is the only one responsible for maximizing the return of investment of the development effort (James & Walter).
- *Scrum Master*
  - It has a leadership role.
  - It makes sure SCRUM process is respected and all the steps are followed accordingly.
  - Filters external messages/interventions so that the SCRUM flow is not interrupted or delayed.
  - Is not involved in taking decisions over the team management.
  - Is responsible in solving impediments that appear in the SCRUM process (James & Walter).
- *Development Team*
  - It has a leadership role.
  - It is composed of 6 (max. 9) members.
  - Plans one Sprint at a time with the *Product Owner*.
  - Has autonomy regarding how to develop the increment.
  - Efficiency is increased when team is working together on a long-term (James & Walter).

To implement SCRUM, the roles managing the software must communicate and collaborate during the whole process of developing the software so that the software is fully maintained and supervised until releasing it to the end user. In order to achieve this, SCRUM defines 5 types of meetings presented in Fig. 1, that must take place in a specific order and that the managing roles must plan and attend to:

- *Sprint planning meeting*: This meeting happens at the beginning of each Sprint and usually in this meeting the *Product Owner* (*PO*) and the *Development Team* (*DT*) negotiate which *Product Backlog Items* (*PBI*) they can fit in the Sprint. Fitting in the Sprint is translated as selecting the amount of work (after an estimate in advance on the duration of each *PBI*) that the *DT* will try to finish as to deliver something functional at the end of the Sprint.

In the process of selecting the amount of work *DT* takes in consideration previous estimations for *PBI's* (if related to the newly *PBI*), possible impediments in the doing the *PBI*, or even lack of technical information related to the *PBI*. The *DT* always "pulls" work from the *Product Backlog* and puts it to the *Sprint Backlog* (James & Walter).

- *Daily Scrum meeting:* This meeting takes place every day and it should not exceed 15 minutes' time. All SCRUM members should be present in the meeting, the main purpose of it being for each member to present the progress of work and if possibly the planned work for the day. Also during the meeting there are to be presented impediments in completing the work if there are any. Another aspect of the meeting is that the members need to stand up during the meeting so that the meeting does not exceed the 15 minutes allocated (James & Walter). The main purpose of the meeting is for the team to collaborate, communicate and create a strong and organized team.
- *Sprint Review meeting:* This meeting occurs at the end of each Sprint and the SCRUM members are ought to present a working product increment to everyone who is invited to the meeting, particularly external stakeholders. The PO has an important role in the meeting as it needs to present all the work the team has done with/without unfinished work as for the attendees to have an overview on the project development status. Also, another very important role in this meeting is assigned to the attendees. They are encouraged to intervein whenever they think it's necessary, ask for clarifications if things are not easy to perceive, or give feedback on the presented items in terms of features or improvements needed to be done (James & Walter). All the necessary changes needed to be done after the feedback given will be put in the *Product Backlog* and implemented in future Sprints after establishing the priority order. This meeting's main purpose is to add value to the product by constantly improving/changing functionalities to adapt to the end user final requirements.
- *Sprint Retrospective meeting:* As like the Sprint Review, this meeting takes place at the end of the Sprint but it's dedicated only to the SCRUM members. One of the main roles in this meeting is assigned to the *Scrum Master* (SM). He is responsible for picking up all the impediments, uncertainties, questions, team conflicts that appeared during the Sprint, confront them with the team and try to find answers along with the team for all of them. The most important role the *Scrum Master* has is to moderate the meeting so that already existing problems to not escalate (James & Walter). The main purpose of this meeting is to find a common understanding for all the problems appeared in the Sprint and take actions to solve them so that the team remains on track in order to move to the next Sprint iteration.
- *Backlog Refinement meeting:* This meeting is the only meeting in the SCRUM methodology that is not necessary to take place but it usually improves the SCRUM efficiency, as it basically prepares the *Product Backlog* for a new *Sprint Planning*. The meeting is all about discussing the *PBI's* in the *Product Backlog* in terms of their description, what they need to achieve, redefinition, deletion or just changing priorities for the *PBI's* (James & Walter).

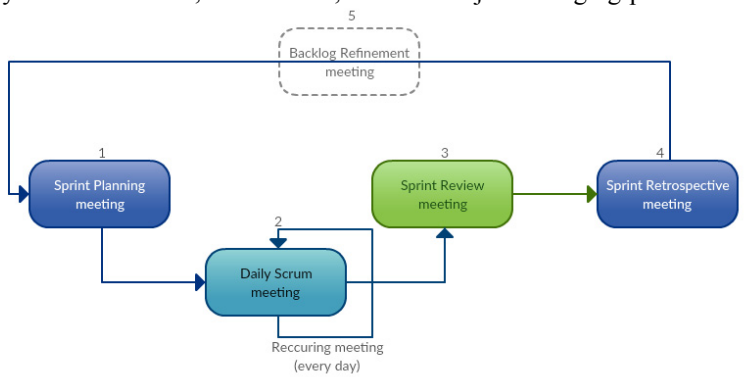

Fig 1. SCRUM meetings flow (James & Walter)

2.2. Internet of Things (IoT)

The *Internet of Things* (*IoT*) is a network developed on large scale and used for connecting smart devices (*Things*) all over the world to communicate together in the same network. *IoT* can be seen as the existing internet network but having different actors in the communication process, called *Things*. From the *IoT* perspective, a *Thing* can be defined as being a smart device that can "communicate" between the *IoT* network and the real environment where it resides (Stankovic, 2014). The communication can be done two ways. The smart device gets the data from the real environment and puts it into the *IoT* network, case in which the smart device acts like a sensor, transducer or any informational capturer, or the smart device picks up the resulting orders after analyzing the data in the network and translates them into actions on the environment where it resides, case in which the smart device acts like an actuator or as an execution element.

By creating an analogy, if in the internet network people have a leading role in the communication process by mostly exchanging data of social/cultural/informational interests, in the *IoT* network the *Things* have the leading role in the communication process, and the data exchanged between the *Things* is mainly informational/executional data taken/given by/to the *Things* from/into the environment they reside in. Usually the data exchanged in the *IoT* network is processed by complex algorithms, resulting in *Things* picking up the best solution for solving the real problem they are facing in the environmental context. The *IoT* network as is developed in the current stage can have lots of interpretations for a *Thing*, but it's also opened to accept all sorts of new *Things* if they can be integrated in the network. Looking through the existing devices in the *IoT* network it can be seen that focus was set in developing devices to help creating smart houses, smart offices, smart buildings or even more the latest concept being that of a smart city which embeds all existing smart devices in creating the concept of a smart city. Below in Fig. 2 is depicted a basic *IoT* infrastructure representing a smart home and its components (Jie, Pei, Jun, Yun & Wei, 2013) (Moser, Harder & Koo, 2014).

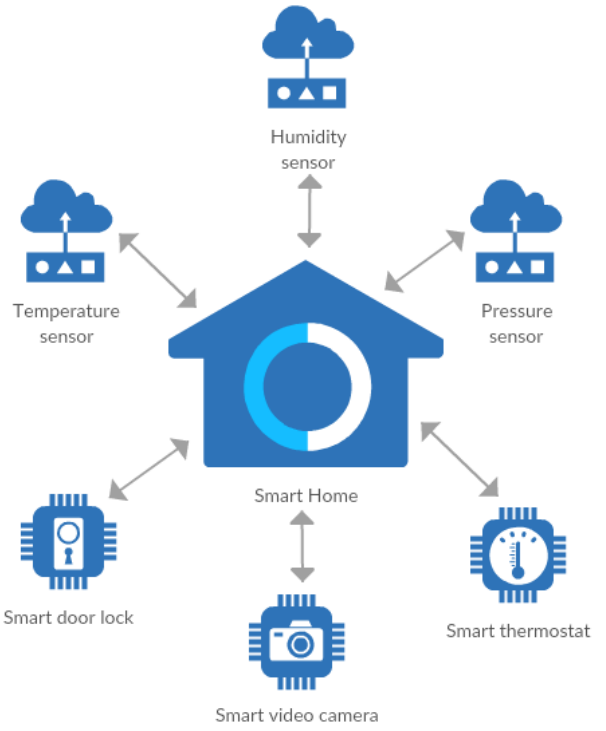

Fig 2. *Internet of Things* infrastructure representing a *Smart Home*

3. *Agile* with *Internet of Things*

As nowadays we are surrounded by technology it is impossible for one not to have at least 2-3 smart devices around him capable of being incorporated in the *IoT* network, in which case means that they communicate with each other to exchange relevant data and provide relevant data to the person near them. By extending this system and taking in consideration the base concept of the *IoT* network that all smart devices are to be integrated in an Internet of smart devices network, we can say that a group of persons can interconnect to exchange relevant data at a certain point in time by taking advantage of the possibility these smart devices can offer. This system of interconnecting people into a group using all smart devices they have available as a support for communication and command can be used as a model in any project management to improve the management process parameters (Lou, Liu, Zhou & Wang, 2011) (Hu, Yuan & Zhang, 2009).

In particular, this paper proposes o software project management solution that applies the above presented system and presents all the benefits that come out of using the system on a group of people that form the project team. The software project management solution is using the *Agile* methodology for planning the resources and the work assigned for the team in the software development process. Effectively the solution integrates/expands the *Agile* software development to use the *IoT* network as a support in all the necessary scenarios like when productivity can be improved, where *Agile* lacks solutions or simply where *Agile* can be optimized or made more user friendly.

As part of the *Internet of Things* devices, used in implementing the solution we included smart task managers, smart boards, smartphones, smart video cameras, smart human detector sensors, smart watches as seen in Fig 3. All the above presented devices are being interconnected and correlated with the *Agile* project management process which is used by a software *Development Team* to produce a final software product to an end user. In the *Agile* process, there are also involved stakeholders and external future clients to create a solid software product.

There are several project management parameters, detailed in the below subchapters, which this integration/expansion improve such as: team performance, team efficiency, team creativity and collaboration or a more optimized process of *Agile* development.

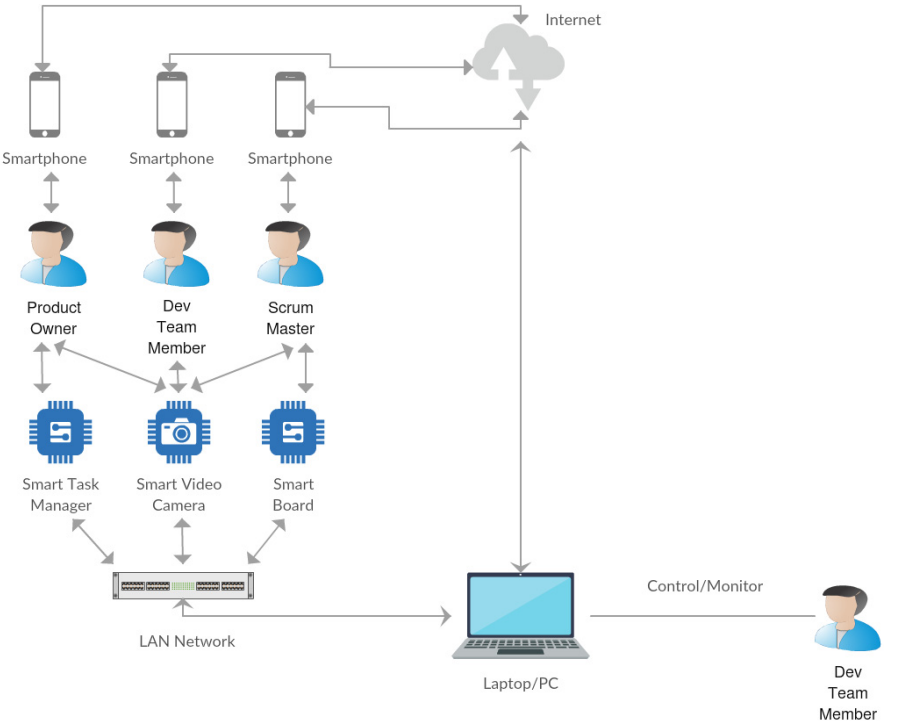

Fig. 3 *Agile* with *Internet of Things* infrastructure

3.1. Team performance

By analyzing the *Agile* meetings' infrastructure and flow and examining the roles of the team members, it can be observed that along the whole *Agile* process the team is ought to stay tight together, communicate as often as possible about the work achieved/required by each member, schedule tasks accordingly to the specified documentation or expose and solve impediments if any are risen during the development phase. During the first years of using *Agile* project management for developing software products these actions implied a lot written documents for managing the scheduled tasks, a very well synchronized team as to meet up for the *Agile* meetings, and a lot of phone calls for solving impediments and for achieving a high level of communication in the team (Kaczorowska, 2015) (Dingsøyr, Fægri, Dybå, Haugset & Lindsjørn, 2016).

A lot of these actions are highly improved in terms of team performance by integrating smart devices into the *Agile* meetings flow, which also has an impact on redefining the team member's roles. The use of smartphones along with a smart video camera practically removes all possible problems regarding the lack of communication between the team members. The applications available on a smartphone software market, that can make possible a live video conference are various, facilitating a rapid and easy communication between each members of the team, regardless of the location of the member. The possibility of sharing screens between these smartphones or with any other 3rd party device such as a PC or laptop practically removes the distance barrier between the team. Having this in consideration we can note that ability of using smartphones or smart video cameras also facilitates the "working from home" practice, over which studies show that highly increases people's working performance (Bloom, Liang, Roberts & Ying, 2013).

3.2. Team efficiency

Another important project management parameter is the team efficiency, a parameter which is influenced by a lot of factors like: project resources, team workload, balance between technical team quality and the high level of difficulty of work, unclear and hard to understand project specifications, analysis and process of large amounts of information within a short time frame. All of the above factors can have a major impact on each member of the team in terms of deteriorating work quality, increasing the time that a particular task is being accomplished, performing tasks very likely not to be useful or in some cases even unnecessary, and finally causing certain imbalances or tensions within the team (Rahayu, Sensuse, Fitriani, Nurrohmah, Mauliadi & Nur Rochman, 2016). Before the smart devices could be integrated into an *Agile* solution these impediments could have been fixed by a bigger amount of calls, discussion or meetings which involved the whole team. The amount of time spent to gather the team in a conference room plus the time spent on these meetings / calls increased even more the time spent for each team member in finalizing the tasks required to do, therefore the workload per team member could have reached a very high level.

The integration of smart devices using the *IoT* network is looking at the cause of the situations presented above, which is the impact of the mentioned factors over the whole team, by trying to decrease or even the eliminate if possible the negative impact set on team's efficiency. Therefore, by using a smart board with the capability of "translating" the written text information in project specifications and adding all the schemas/figures from a brainstorm session into the project specifications will highly reduce the time spent for a *Product Owner* and *Scrum Master* in defining the product specifications. Also, the use of a smart board during the *Daily Scrum Meetings,* by adding eventually changes to the specifications, has a major impact in decreasing the time in which a task is being finished as for the uncertainties can be clarified by redefining a task description. The use of smartphones for communication purpose is replacing the conference room meetings eliminating that extra time spent on the organizing/attending the meetings within the team which is helping in reducing the workload of the team.

Though it is not a palpable smart device a smart task manager is one of the most important devices that can eliminate the negative impact most of the factors presented can have on the project team efficiency. A smart task manager acts more like a software task manager (task manager algorithm) and it is used to set up the tasks in the priority order, set estimates on tasks that are similar to other tasks already done based on an artificial intelligence like algorithm, or eliminate/redefine/reprioritize tasks that are not likely to be useful or unnecessary. This smart task

manager acts almost like when all the team members are continuously discussing on task descriptions, estimations and necessity of *Product Backlog* tasks, highly reducing the amount of time spent by the team in re-discussing what the smart task manager have already decided. We need to mention that the decision on the actions to be taken will always be the in the hands of the team but by using a smart task manager there will be plenty of work time available for each team member to spend on developing the product.

3.3. Team creativity and collaboration

Team creativity is another parameter affected by *IoT* integration into *Agile*, although it is not easy to quantify or list the exact positive effects of this on the *Agile* project management process. However, it can be easily noticed that as the first *Agile* project management solutions asked for a lot involvement from each team member in making *Agile* worth to be used, the amount of time left for the members to actually do their work was small, and mostly all of it was spent to effectively work on software development tasks (Whitworth & Biddle, 2007). The planning meetings were used mostly for the team to understand the requirements set by the *Product Owner* and not implying the *Development Team* so to improve or redefine requirements if needed for the product to become more valuable. The *Development Team* had almost no implication in adding value to the final product in terms of creativity side of things, and this was mostly because there was no time for the *Development Team* to spend in setting up the requirements for the product. As mentioned above, there is no measurable tool to evaluate the how the creativity of the *Development Team* can improve the final product in terms of making it more reliable, scalable or user friendly. Giving the *Development Team* more time to get involved in brainstorming for a new or better solution or even redefining the existing ones could add value to the final product (Liubchenko, 2016).

The use of smart devices in the *Agile* project management process slightly changes the situation in terms of team member roles and time that they will allocate for making the project *Agile*. As depicted in the above paragraphs the use of devices such as: smart task managers, smart boards, smartphones or smart video cameras highly reduces the amount of time spent for each team member making the project *Agile*, therefore increasing the team performance, team efficiency and leaving time to spare for each member to involve in improving the value of the product. The collaboration of the *Development Team* for adding value to the product can be done in two ways: each of the team members can take initiative during planning and refinement sessions to help create specifications, define requirements, plan resources, establishing task descriptions and priorities, or by giving each of the team's member a large freedom in deciding over the product's development mode as to bring as many ideas as possible which will improve the value of the product.

4. Conclusions

This paper presents a software project management solution that uses *Agile* project management concepts for managing resources, activities or development tasks and integrates *Agile* in the *Internet of Things* network to use smart devices as agents of communications, actuators or even giving them management roles in the *Agile* project management process.

The contribution of the proposed solution consists in the improvement of the *Agile SCRUM* methodology in terms of increasing the efficiency of *SCRUM* process by just simply involving smart devices that can take work of Team Members, increasing team productivity by optimizing the usage of resources and improving the communication process between the Team Members by using all the smart devices available for this purpose and last but not least the solution proposed gives Team Members more time to be used in creating features and improving the final product by letting the smart devices handling some of the members work.

The purpose of integrating these two concepts was to overcome the difficulties appearing when using *Agile* project management regarding the communication between the team members, different time zones where team members are working from, lack of technical support to respect *Agile* concepts, or to improve parameters like team performance, team efficiency, team collaboration, resource planning.

The infrastructure of the proposed solution is designed to support any new smart devices that might appear in the *IoT* network, the integration of which will be carried out by each team by incorporating the new device into the *Agile* project management.

It can be noted that by using a smart task manager device for managing the *Product Backlog* the resource planning process becomes more efficient and it allows the team members to pick up any tasks that they could do without having to attend to the *Sprint Planning* meeting.

The integration of smart boards and smart video cameras in *Sprint Planning* meetings or *Backlog Refinement Meetings* improves the time and costs spent on writing the specifications/descriptions/task assignments by just adding to the *PBI* images/videos from the meetings which will replace the old habit of having text documents set to a *PBI*.

The use of smart devices is an efficient way in which a software project management solution will improve team collaboration, have a more efficient and rapid team communication, optimize resource planning, increase accuracy project requirements and finally optimize the team management and product development process.

The solution presented in the paper uses latest technologies in terms of smart devices and for future improvement of the solution the focus is to be put on updating the smart devices to new ones as to keep in touch with the latest technologies. Also, there is to be considered that the devices used need to have an impact on the solution by improving the SCRUM process parameters or even enlarge the spectrum of parameters that will be improved in terms of efficiency.

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