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Table of Contents

In the last decade, WSN used in various aspect of environmental conditions monitoring. due to Rise in the population, climate instability, and unregulated groundwater mining threaten the preservation of aquifers worldwide. Effective and data-driven control of groundwater supply is essential for sustaining critical water-dependent functions. Recently, the water crisis in Yemen has become a problem threatening the lives of many residents. This is due to the manager's lack of cost-effective, scalable, and reliable groundwater monitoring systems needed to gather vital groundwater data. In this study, we developed a fully automated real-time groundwater level system for data collection and visualization based on wireless sensor network (WSN). The study was applied in Taiz City, Yemen. The steps used to develop the system, including dividing the study area into different zones, and each zone uses a local base-station to collect the data from the sensors deployed in the same zone. All local base-station send the data to the master base station located remotely. The master bases station collects the data and sends it to the web-servers that are used to save and visualize the data permanently. The proposed system was designed and evaluated using the web design techniques and the system performance investigated based on network bandwidth and the sensors' power consumption.	

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Article

C-MPE: A Collaborative Multiprogramming Development Environment for .Net Framework

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Abstract

Working in a team has a great influence on the success of a multi-user activity. Software development is a type of these activities that are highly collaborative between the software development team. Collaboration between the project's team improves the user experience which leads to improving the project quality. Thus, collaboration between the development team requires a development environment with collaborative capabilities. In this work, we develop a collaborative multi-programming development environment (C-MPE) that enables software developers to share the software components between geographically dispersed teams connected via a private network. C-MPE permits developers and programmers to build their own environment with custom properties and link them with a non-open-source framework such as the .Net framework.

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1. Introduction

The development of software applications has gone through multiple stages, starting with a single developer in the project to paring programming [1], and then collaborative programming. Pair programming is a method of collaboration in which two programmers work on a programming task on the same machine. It is a collaborative method of working that involves communication, clarifying ideas, discussing approaches, and coming up with better solutions. While pair programming is beneficial, it requires practice and is constrained by the physical existence of the pair. In a collaborative development environment [2] the teamwork of a project, even if distributed by time or location, may share knowledge, discuss, negotiate, brainstorm, and carry out some task. The development and integration of large software systems is a difficult process for a single developer. Thus, the systems are divided into modules and components and then assigned to teamwork. The enhancement in the computer networks and the Internet made it easy to build teamwork even if they are located in dispersed locations and take advantage of these advances in migrating from a single and local environment to a global and distributed environment. Moreover, recently, the COVID-19 pandemic imposed social distancing laws, which had a major impact on forcing the teamwork to communicate remotely through private networks or the Internet.

Many open-source control and development environments and tools have emerged and support collaborative programming, project management, and control. GitHub [3], is one of these tools that enable developers to use the benefits of code hosting to access a project centrally. Developers can develop projects and contribute to an existing project no matter where they are in the world. Other similar tools that enable public and private development collaboration are SourceForge [4], cloud9 [5], Eclipse [6], Microsoft Visual Studio live share [7], and Space [8]. These tools offer the ability for team members to work remotely, in real-time, to write, debug, and run code. These tools are powerful tools but most of them are commercial ones, only limited capabilities are provided in the free versions.

The .Net framework [9] is a software development framework developed by Microsoft and runs mainly on Microsoft Windows operating systems. It is constituted of two main components called Framework Class Library (FCL) and Common Language Runtime (CLR). The FCL provides the user interface, data access, database connectivity, cryptography, web application development, numeric algorithms, and network communications while CLR is a virtual machine that provides services such as memory management, security, and exception handling. It is responsible for executing programs written for the framework. Fig. 1 shows the major components of the .Net framework.

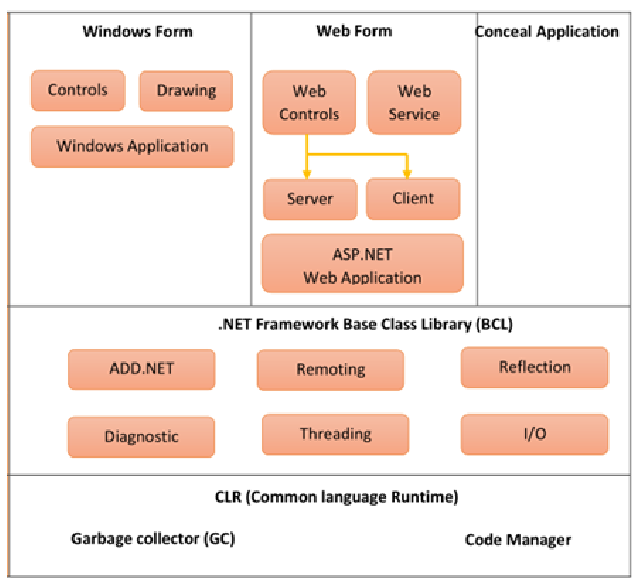

Figure 1: .Net framework architecture [9]

2. Related work

Many researchers have worked on developing an integrated environment that helps teamwork to communicate and share experience and code. Collaboration features help in improving communication between the developers which results in enhancing and speeding up the development process [10].

At the early stages of the collaborative IDE development, IBM developed a collaborative IDE called Jazz that adds a set of collaboration features for the Eclipse IDE [11]. Sangam [12] is another plug-in for Eclipse that introduces a shared editor and chatting for pair programming Langton et al. [13] addressed this issue by presenting a tool called Group Homework Tool (GHT). This tool is developed to help programmers code in a synchronous collaborative manner. It concentrates on student group teaching assistants and tutors. GHT has many features such as HTML frames for an assignment definition, asynchronous code editor, chat, and a shared Whiteboard. The major drawback of this work is the high latency imposed during the communication. A collaborative IDE is described by Hupfer et al. [14]; the main purpose of the IDE is to provide a communication medium between team members enabling them to discuss issues related to the project. Hani et. al. [15] presents the design and implementation of a collaborative IDE called ICI. It enables developers to edit, share, compile, run and debug software projects in real-time. Aditya Kurniawan et. al [16], proposed a real-time collaborative code editor called (CodeR) using web socket technology. CodeR provides workspaces to build and execute the source code in real-time in addition to the chatting capabilities. In order to obtain fictional collective programming scenarios, Chunhui Wang et al, [17], formed a group of physically-distributed programmers to collaboratively solve a programming problem. He observed that any programmer's submission may possess information that could provide inspiration for others in the teamwork even if the submission is not completely correct.

The aim of this paper is to present our experience designing and implementing a collaborative integrated development environment called (C-MPE) that enables work teams connected by private networks to work in one project. It permits developers and programmers to build their own environments with custom properties and link them with the None-Open-source .Net Framework.

3. The Architecture of the C-MPE

C-MPE is a collaborative integrated development environment that enables developers to create projects, share programming-related tasks, and collaborate on a variety of software development activities in real-time such as editing, compiling, running, and debugging. It consists of two main parts; the first part is the IDE itself where all the project-related tasks can be accomplished. The second part is the core part of the C-MPE where we connect to the .Net Framework core and use it to compile and run the source code.

3.1. The integrated development environment

The integrated development environment is the first part of the C-MPE in which all development is performed. It combines the common activities of writing software such as editing source code, building executable, and debugging into a single application. In addition, it supports code auto-complement and color-based error detection, syntax highlighting, and autocomplete.

Figure 2 shows the IDE panes, the code source code pane, project explorer, output pane, and the list of the active developers.

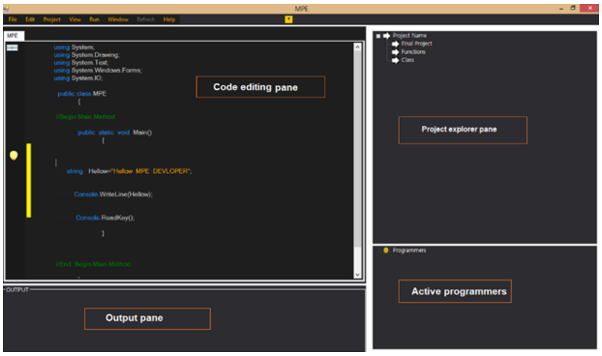

Figure 2: The panes of the MPE-IDE

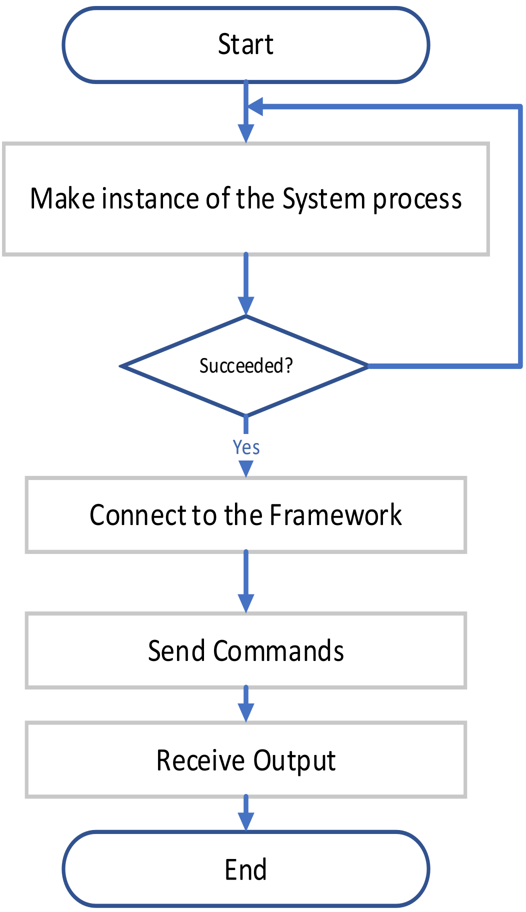

Figure 3: The connection method to the .Net Framework

3.2. Integration method with the .Net framework

The challenging part of this work is how to connect with the .Net framework in order to use the class libraries and language interface without using the Microsoft platform cross-platform version of .NET that is maintained by Microsoft and the .NET community. Thus, we proposed and implemented a method that connects externally to the .Net core and uses its class library and management facilities. Figure 3 shows the steps followed to connect to the .Net framework from the IDE environment.

The method works as follows: First, it makes an instance of one of the operating system tools such as PowerShell or command line interface that allow communication with all system parts. This process emulates the operating system and gets all the power and privileges necessary for sending commands as an input and receiving the output results. After a successful connection, it starts sending commands and then receiving the output of the process.

3.3. How C-MPE works?

The method works as follows: First, it makes an instance of one of the operating system tools such as PowerShell or command-line interface that allow communication with all system parts. This process emulates the operating system and gets all the power and privileges necessary for sending commands as input and receiving the output results. After a successful connection, it starts sending commands and then receiving the output of the process.

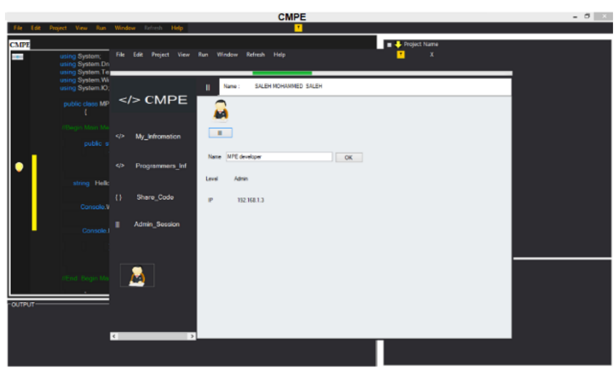

Figure 4: Adding programmer to the project

Once the project leader assigns the tasks to the programmers, the project will be cloned to the programmer machine. Then each programmer can work on the modules, classes, or methods assigned to him, Fig 5. If the programmer made any changes, he has to commit the changes and synchronize with the rest of the team in order to get the updated versions of the project. If any of the programmers worked offline, synchronization will start as soon as he connects to the project leader machine.

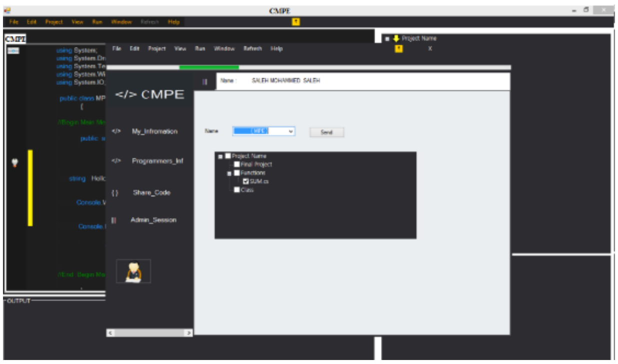

Figure 5: Assigning tasks to the programmer

4. Technical Challenges and limitations

The C-MPE is tested under different types of projects and worked fine, however it faces some technical and performance challenges. Connecting to the operating system instance results in a delay compared to the native connection found in the .Net framework. Moreover, the C-MPE is limited to working only on private networks. The current version of C-MPE supports only one C# language of the .Net framework and restricts the programmers to work only on the modules assigned to them.

5. Conclusion and Future Work

Collaborative software development gains popularity due to the enchantment in the network and communication technology. A group of developers can share the development of the project even if they are located in different locations. Based on that, we have developed a collaborative development environment for the .Net framework that helps developers work together on a software product. C-MPE is constituted of two major parts. The integrated development environment and in addition to the core method that makes use of the .Net framework core services to build and execute the programs. The preliminary results show that the C-MPE can be used to develop and share applications between teams over a private network. In future work, C-MPE will be enhanced to support multiples languages of the .Net framework. In addition to the enhancement in the speed of the synchronization process. Moving C-MPE to use the Internet-based .Net framework is another forward step that will be taken into consideration in the upcoming enhancements.

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Article

BScrum: An Agile Development Method for Blockchain Software Development

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Abstract

Blockchain system is of the most recent invention, which brings more challenges to software developers. To overcome these emerged challenges, software engineers should invent engineering methods that covers the whole process of blockchain system development. However, currently, there is a serious lack of mature development methods. In this paper we present BScrum, an agile method to eliminate issues related to blockchain system development. From agile methods, the proposed method is based on Scrum, which in turn makes the development process is manageable and incrementally delivered. BScrum method covers the whole development process in details to fill the research gap and to advance the research body of knowledge.

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1. Introduction

Technologies are continuously and rapidly growing, which advance many aspects of our life. Nearly a decade ago [1], new emerging concepts called blockchain and smart contract have attracted the attention of noticeable number of researchers and industries [2]. One of the main reason behind this popularity is because of the promises that blockchain brought. Currently, it is an deniable that blockchain is recognized as the fifth evolution of computing because it is considered as a trust layer for the internet [3]. Blockchain has changed the traditional business process since its onset, in which the business process can operate in a decentralized architecture instated of centralized in a trust way [1].

The system architecture of blockchain is peer-to-peer, which makes the system redundant and transparent [4, 5]. Therefore, it provides a trusted environment that does not need the involvement of third party [6]. This is perhaps one of the most influential factors for the popularity of blockchain adaption in different domains. This brings undeniable challenge, in which every domain has its own specific requirements to ensure the success of this adaption. Therefore, adhering to software engineering development methods is mandatory to ensure the success of the project and to deliver it within the specified time and budget.

Software engineering is an old but continuously growing and active field whose focus on system production from initial conception to maintenance [7]. It is essential for developing any kind of software ranging from embedded systems to systems of systems such as cloud computing. Therefore, adhering to software engineering principles and methods during the development process of blockchain system is not an exceptional. However, software engineering offers a wide range of methods which introduces a difficulty for developers to choose from especially when developing new systems with new theories such as blockchain systems.

Plan-driven is one of the essential and old software engineering approaches, which has been used widely. The concept behind this approach is that, software activities are separate and each activity should be done before moving into the next activity as depicted in waterfall model. This implies that, system requirements must be understood and stable from the beginning. Despite the fact that this approach is better for addressing security issues, agile approach could deliver the required software faster than plan-driven without compromising security [4]. According to agile manifesto “We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value: Individuals and interactions over processes and tools Working software over comprehensive documentation Customer collaboration over contract negotiation Responding to change over following a plan”. Therefore, by developing blockchain systems using agile methods developers could deliver systems faster than following plan-driven approach. As a natural result from the popularity of agile approach, several methods have been emerged, including Scrum, Extreme Programming (XP), Crystal, Feature Driven Development (FDD), Adaptive Software Development (ASD) etc. A cording to this manifesto, agile pays more attention on the code to deliver software as fast as possible and it reduces the documentation which is very important for maintenance. To overcome this issue, agile adapts refactoring principle in which developers should look back to the code that have been done and make it very clean and understandable.

According to K. Schwaber [8], "Scrum increases flexibility and produces a system that is responsive to
both initial and additional requirements discovered during the ongoing development". To the best of our knowledge, the requirements of most of the current systems are not fully understood and changeable due to some reasons such as involving new technologies and market changes. Thus, Scrum is a suitable development method for the current systems including blockchain.

The process of developing blockchain systems is not similar to the process of developing traditional systems. According to [9], there are some critical software engineering components that impact the success of blockchain systems development including requirements collection and tasks assignment among the team members. Since the market is a dynamic environment, in which new products, business strategies and polices are involving contentiously, systems' requirements are certainly not fully understood by developers, and could be changed at any time. To tackle this serious issue, we have to utilize software engineering best practices with taking into consideration the special blockchain system development process as will.

Therefore, this paper extends Scrum method which is one of agile method that is most widely used [10]. The extend method is called BScrum to suite blockchain system development process with distributed team. The reminder of this paper is organized as follow: section 2 discusses some related work. Section 3 presents in detail the proposed method. Section 4 concludes this paper.

2. Related Work

New technologies and techniques are emerging continuously as a response to the business and mark needs. Blockchain is a technology that is recently emerged which has not reached its maturity. Therefore, many researchers have paid attentions to advance this technology from different perspectives.

From software engineering perspective, precisely from development process there is undeniable effort toward aligning the blockchain development process with software engineering practices [11]. Preliminary steps towards modeling blockchain oriented software (BOS) were proposed by Henrique Rocha and S. Ducasse [12] with the aim of standardizing the designing and molding the BOS. They focus on three modeling standards including entity relation (ER) for data driven, unified modeling language (UML) for structure driven, and business process model and notation (BPMN) for process driven. However, [13] proposed blockchain lifecycle to link between business process management (BPM) and internet-of-thing (IoT).

From blockchain use case point of view, Gilbert Fridgen etl [14] proposed a method for development of blockchain use case as a systematic approach to improve the understanding of potential of blockchain and to develop sound use cases. The proposed blockchain use case development method has six stages. However, this proposed method focus only on use case development where other aspects of blockchain system development were neglected.

In contrast, Michele Marchesi etl [15] proposed a full software development process. The common activities including requirement gathering, analyze, design, develop, test and deploy blockchain applications. They claimed that, the proposed process is based on some agile practices with the use of some UML diagrams. It is worth mentioning that agile methods are usually used when the requirements are not fully understood from the beginning [7]. Therefore, it is difficult to separate the development process activities to make the process able to cope with requirements changing.

A method based on model driven architecture was proposed in [16]. Authors claimed that the proposed method might be used for defining and specifying blockchain structure and behavior. This is to facilitate the development of a blockchain-based system. Nevertheless, this method does not provide detailed descriptions about its usage.

One of the most recent and excellent work was done by Lodovica Marchesi etl [4]. They proposed ABCDE as a method for blockchain software development. This proposed method is based on Scrum, but it differs from Scrum as it separates the development activities into two parts, one for smart contract development and the other one for the software that will interact with blockchain. However, our proposed BScrum method is oriented and focused on blockchain system development with the focus of distributed team management.

3. BScrum Method

In software practices, plan-driven and agile approaches are the well-known and used development approaches and it is difficult to say that one is better than the other. This is true, because plan-driven is more suitable than agile approach for some projects, while agile approach is more suitable than the plan-driven in anther some projects. Despite the advantages and disadvantages of those approaches, agile approach is used when the project requirements are not fully understood, and when the requirements are unstable, which might be changed during project development process. From agile methods, we have extended Scrum method to ensure better blockchain system development. The main reason for this, is that Scrum provides project management and shows external visibility of what have been done in the project [7]. In addition, it helps managing the distributed development teams, which is the nature blockchain development process. The proposed BScrum method is illustrated in Figure 1.

3.1. Project goals

Any project should start with clear goals, which should be written very clearly and briefly with few words up to 30 words summarizing the project goals and make them visible to the whole team [4]. This is a good software practice which allows every team member who involved in the project development to know the project goals.

3.2. Product backlog

It contains the list of project requirements which is the responsibility of product owner to manage this list in a form of user stories [17]. This is due to the fact that, agile methods do not approach the requirements as a separate engineering activity, instead they handle requirements elicitation during the development activity. The idea behind that is to cope with requirements changing and understanding. One of the main tasks that assigned to product owner (or representative) is to prioritize which story should be developed and delivered first. Therefore, the first release of the product is delivered first. We highly recommend that, the first release should contains the most critical and argent requirements for several reasons. Of these, perhaps the most important one, the first release is subject to be tested more than others, which increased the security of the system. This is very important for blockchain systems where the security is one of the main and critical concerns. It is obvious that, product backlog should be visible to all team members as the product goals.

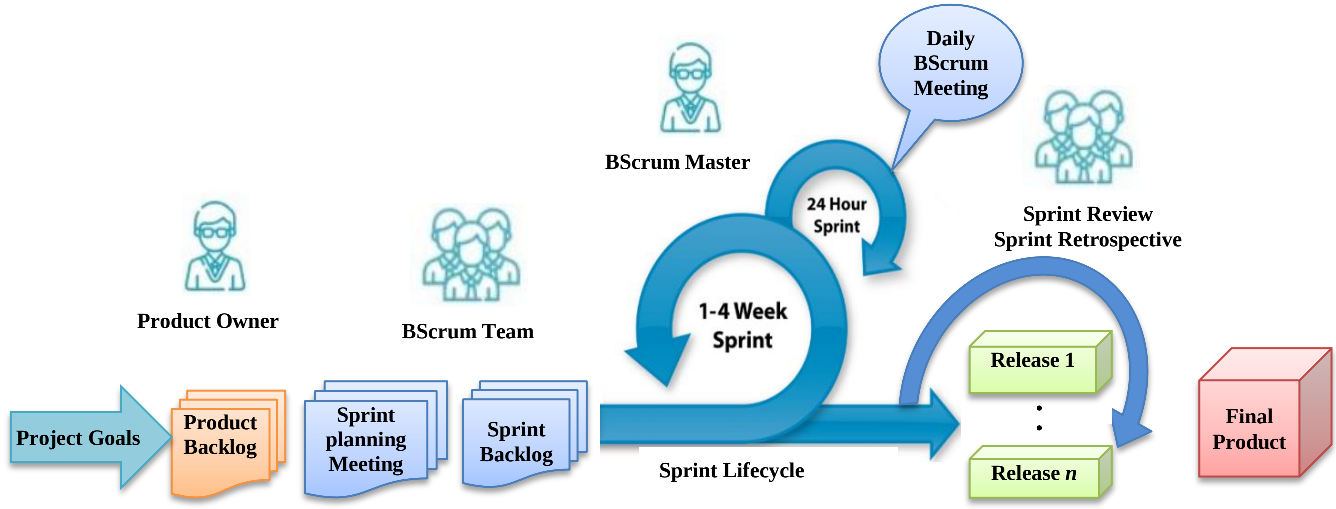

Figure 1: The proposed BScrum method

3.3. Sprint

A sprint is a period of one week up to four weeks in which at the end of the sprint a potentially release is created. Sprints are completely separate, thus it is impossible to start a new sprint until the pervious one has been completed. BScrum recommends allocating a day for sprint planning and a few days for sprint retrospectives. The goal of every sprint is to deliver some user stories within the sprint period.

3.4. Sprint planning meeting

This meeting is held at the beginning of each sprint with present of BScrum master, team member and product owner [18]. This meeting should take enough time up to a day to discuss what requirements should be implemented in this sprint and what is the outcome of this sprint. Since BScrum support distributes team work, we highly recommend using videoconference to allow the participants to effectively share their opinions. It is worth mentioning that the team members could exist in different time zone. To tackle this issue, BScrum masters (the Scrum master of every team) should arrange for meeting to share and discuss the opinions of their teams.

3.5. Sprint backlog

After requirements prioritizations, some user stories are chosen to be developed in a sprint based on team velocity. The selected user stories are broken down into small and manageable tasks. Therefore, team members start the development process by selecting tasks from sprint backlog.

3.6. Daily BScrum meeting

This daily meeting called a stand up meeting which is typically takes no more than 15 minutes. The focus of this meeting is to discuss what have been done since that last meeting, what should be done today, and review the progress. They should look back to the sprint backlog to maintain project progress.

3.7. Release

A release is a part of the whole project which is the outcome of a sprint. It contains some user stories that have been developed within the sprint period. Every release is added to the previous release until the final product is done. Customer could get the advantage of these releases before delivering the complete system.

3.8. Sprint review and retrospective meeting

It is one of the core concepts of Scrum to make a review at the end of every sprint. This review is conducting by the whole team members, BScrum master and product owner. This meeting should answer three primary questions "What has been good during this sprint?", "What has not been that good?" and "What kind of improvements could we do?" [16]. Answering those questions is one of software engineering best practices that help improving team experience and communication. Nonetheless, participants can discuss the quality issues and the problems that faced the team and how to overcome them.

3.9. Final Product

The final product is conceptually drowned by project goals. The result from integrating all releases is the final product, which contains all user stories that have been implemented in all sprints. It should meet the project goals and delivers all system requirements.

4. Conclusion

Blockchain system development is lack of mature software method to enhance the development process. Thus, this paper proposed an agile method called BScrum to improve the management of blockchain system development process with distributed team. This method is based on the well-known Scrum method, which has been proofed as one of the best software development process. In the future work, we are planning to develop some case studies to demonstrate the real applicability of the proposed method.

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Article

Evaluation –Based WSN For Groundwater Monitoring System

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BScrum

Abstract

In the last decade, WSN used in various aspect of environmental conditions monitoring. due to Rise in the population, climate instability, and unregulated groundwater mining threaten the preservation of aquifers worldwide. Effective and data-driven control of groundwater supply is essential for sustaining critical water-dependent functions. Recently, the water crisis in Yemen has become a problem threatening the lives of many residents. This is due to the manager's lack of cost-effective, scalable, and reliable groundwater monitoring systems needed to gather vital groundwater data. In this study, we developed a fully automated real-time groundwater level system for data collection and visualization based on wireless sensor network (WSN). The study was applied in Taiz City, Yemen. The steps used to develop the system, including dividing the study area into different zones, and each zone uses a local base-station to collect the data from the sensors deployed in the same zone. All local base-station send the data to the master base station located remotely. The master bases station collects the data and sends it to the web-servers that are used to save and visualize the data permanently. The proposed system was designed and evaluated using the web design techniques and the system performance investigated based on network bandwidth and the sensors' power consumption.

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1. Introduction

Groundwater is the primary source of water for 80% of the population in Yemen, and it is the second source of water after surface water resources [1]. In recent times, the drought problem threatens the economic and agricultural lives of many of the society's residents. In coinciding with the scarcity of rainwater, the dramatic increase in population, and random urbanization, in addition to the complete absence of water management, groundwater consumption has become five times the annual recharge rate [2]. There is a complete absence in how to manage and allocate the use of groundwater, as it is used by 90% in the agricultural aspect. Groundwater management suffers from many difficulties, and the most notable of these is the access of work teams to well sites. Since they use traditional methods to collect data manually, the accuracy of measuring groundwater levels is inaccurate. Therefore, monitoring systems lose their functions and do not perform well. In addition to that, the expansion of drilling wells and the use of large depths reduce the quality of the groundwater and increase the cost required for pumping [3]. Using an automatic monitoring system for groundwater fields is the most important effective solution [4]; this was the motivation for designing a wireless remote sensing system to monitor these fields. It provides full knowledge of decision-making systems for making future strategic decisions and plans, such as laying pipes for drought-affected areas and the development of policies that organize groundwater management operations and reduces these crises [5].

Recently, Wireless sensor networks are widely used in all aspects of environmental monitoring applications, and environmental conditions variation as pressure, weather condition, temperature [6]. WSNs support the lowest duty cycle monitoring application [7] [8]. WSN consist of connected small electronic devices (sensors) uses to collect precision and real-time data at a different location [9]. The environment of water is considered as a factor that effects on the WSN to monitor and get the efficient points [10]. 6LoWPAN (IPV6-based low-power personal Area Network) is low-cost, reduced energy consumption defined by Internet Engineering Task Force (IETF) to enhance the WSN by adding TCP/IP implementation [11]. 6LoWPAN allows many wireless networks to connect with each other via the internet and offer IP communication by implementing a new layer. This layer is adaptation layer which implemented by routers at the edge of 6LoWPAN regions to represent the physical and MAC layer of this protocol to make compatibility the ipv6 packet with IEEE802.15.4 link [12][13].

This paper aims to design a real-time groundwater monitoring framework to help manage and reduce the loss of groundwater. The sensors node gathers some. of precision water's parameters as, PH, dissolved oxygen and so on. The proposed framework uses a web site to visualize the collected data.

2. Previous Studies

The development of groundwater monitoring systems took the interest of many researchers and conducted many studies. In [14], the system has been proposed to manage the changes in the water resources over time and offer long term groundwater level data. They used a data logger as a component to measure the water level and stored recorded data in the database. The system uses GIS to manage the data of water level and visualize the information to the user to understand the relation between borehole's location and topographic. J. Wang et al. [15] proposed a water monitoring system based on

WSN with ZigBee protocol. ZigBee node uses GPRS/CDMA techniques to forward data to the base station. A set of fixed sensors were deployed in the study area to monitor a different kind of water parameters. In [16] they developed a system that depends on the context of electrical conductivity of water to measure the water level using water level sensor and Microcontroller, water level indicator. The water level was implemented on the tank to determine the state of the tank (i.e., empty or full) to control the pump operation. The main finding of this study is to investigate the idea of water management.

Another study in [17] implemented the cluster structure of wireless sensor networks in the department of the kingdom of Saudi Arabia to monitor the water quality of water resources. A vast number of sensors were deployed to collect the data, and the controller used to forward the data to the central unit. Real-time wireless monitoring and control of the water system using ZigBee 802.15.4 in [18] designed to monitor flood areas, reservoirs, rivers, and automated the operation of the pump. They use PH sensors, oxygen dissolved sensors to monitor water quality—the data sent from e node to the coordinator by the router through wireless technology. Many emerging technologies are used in this study such as: ZigBee, GSM and 74HC14 Hex Inverting Schmitt Trigger. In which the Schmitt used to reduce the cost of the system. GSM technology has been used to send data to user's phones from the flood area. This system implemented a testbed on water tanks. The proposed structure designed to automated the well's operation and monitor essential parameters of water quality, water level and EC by using WSN based on IEEE 802.15.4. It uses wireless sensors deployed at twenty-four wells of the agricultural area of Karbala, Iraq. The data movement in the network is controlled by the PAN coordinator. The operation of the pump is automatically controlled by the PAN coordinator decision. Collected data will be relayed to the main base station wirelessly. However, this system does not offer remote control [19]. Real-time groundwater level observation (GWO) application depends on WSN, programing language (R language), and an open-source framework in the South American Sub-basin of California.

They found pressure transducers sensor is more suitable for giving groundwater level time series data than manual water level meter measurement [20].

3. Methodology

The main structure of the proposed system is shown in Figure 1 it encompasses four main parts: study area, base stations (BS), web server, and end-users. The study area is divided into four different zones, and each zone uses a local base-station to collect the data from the sensors deployed in the same zone. All local base-station send the data to the master base station located remotely.

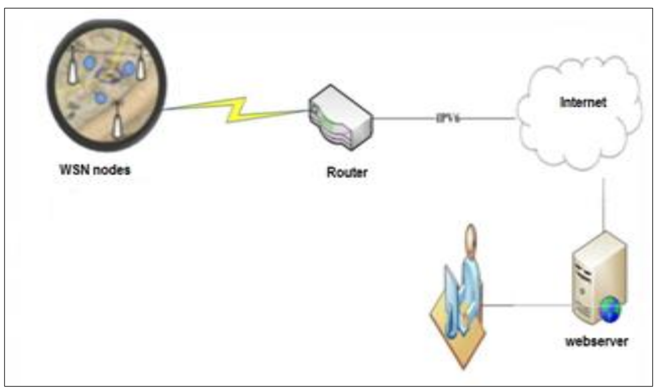

Figure 1. Groundwater Network Architecture

The master bases station collects the data and sends it to the web-servers that are used to save and visualize the data permanently. The data saved on the web-server based on a web-model developed to help reduce the traffic (see Figure

2). This model passes through three stages: safe, updating, and visualization, more details of these stages as follow:

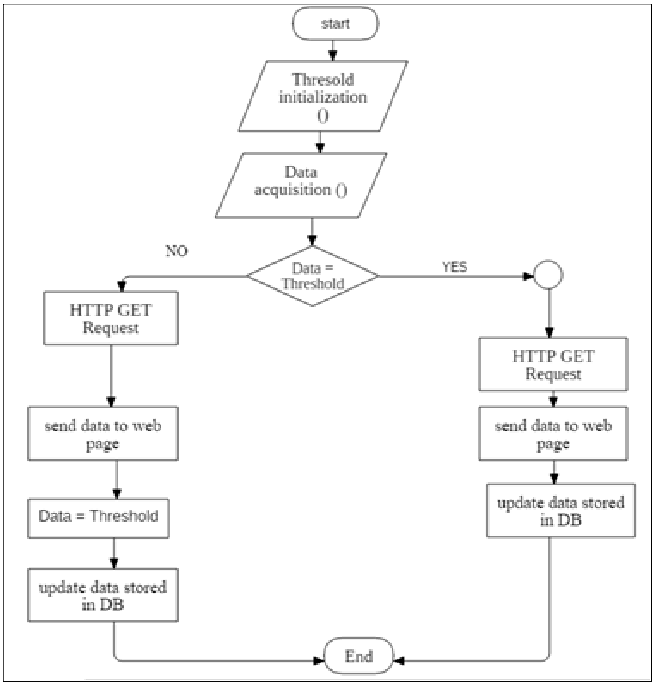

Figure 2. Flow chart of updating DB

3.1. Data safe

All data were collected from the study area, which considered well's data are stored in the SQL Database to be safe for a long time and visualize using web-application. The database consists of monitored well's characteristics as name, number, groundwater level and time and date of sensor reading.

3.2. Data updating

Because we are continuously collecting data in real-time, we need to keep the data updated in the databases. Figure 3. shows the algorithm used to update the data in the database. The updating process depends on the threshold value, which is the initial data collected from the field. The backup of data was considered to avoid indirect data loss caused by any unexpected malfunction in the network and the data saved in the SQL database on the cloud.

Data visualization

Once data stored, it visualizes to the end-users by using a web application (website), which is connected directly to the SQL database. Detail information about the well's area and level of groundwater visualize to end-users in real-time. It allows the users to interact with data and manage it in an efficient way anytime from anywhere.

4. Results

As mentioned previously, the proposed system was designed and simulated using the web design environment. Different experiments have been applied; the first experiment is to measure and evaluate the communication between the water level sensors deployed in the study field and the local base stations in each zone. The second experiment is to measure and assess the communication between local base-stations and the master base station that use to collect all packets and forward it to the web-server. The performance matrices used to evaluate the proposed system are the number of packets and the energy consumption of each sensor. Different communication technologies have been used to manage the connection between the sensors and the local base station, and the local and master base stations

Figure 3 indicates the main structure of the proposed system that shows the communication method of communication in different layers. The first layer, the communications between the sensors and the local base-stations, uses the ZigBee that allows for the packets to be transmitted for a few meters. The second layer, the communication between local and master local base-stations, and for this long-distance communication technology such as Lora or 3G used to transfer the packets. The third layer, the

communication between the master base-station and the web-servers, the 6LOWPAN communication technology used for this part.
Last part, our application (website) is designed to save and visualize the data on the web server and to determine the change in well field storage. from the page in Figure 4 the end user can be accessed to the characteristics of the wells by selecting the well name based on choosing Isolation, Directorate and owner.
When desired well selected Figure 5 shows such an example from the website; in this result, the data collected from the study filed are presented with a full description of the data such as location, date, depth of wells, etc.

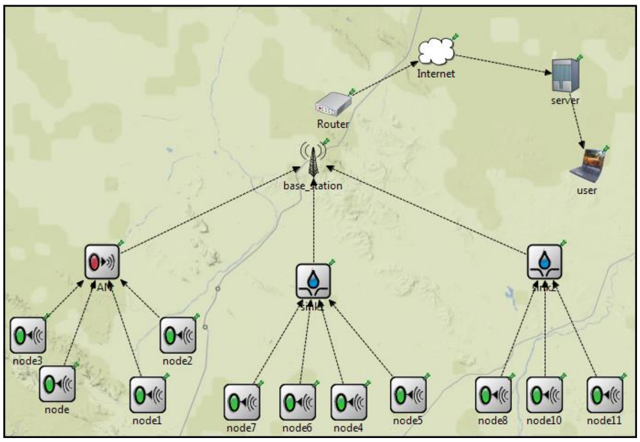

Figure 3. present a snapshot to the structure of framework designed

Owner's name : Yosof
Show Well Data
Show Well Status
Valley / Village Name : The fog
Show Well Data
Show Well Status
Isolation Name : Hathran
Show Well Data
Show Well Status
Directorate name : Mountains Habashee
Show Well Data
Show Well Status
Hom

Report on the wells in the province of Taiz

Directorate name	Isolation name	Village / Valley	Well number	Owner name	Type of well	Currently Available Water	Well condition	Depth of well	Width of well	Warning level	Date of registration
Mountains Habashee	Hathran	The fog	1	Yosof	Tubular	2562	Work	1114	2	5	2020-05-22
Mountains Habashee	Hathran	The fog	2	Corporation	Tubular	65111	Work	1104	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	3	Ghee factory	Tubular	25773	Work	1067	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	4	Grop Haul	Tubular	109423	Work	1082	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	5	General authority	Tubular	77872	Work	1148	10	3	2020-05-22
Sala	AA	Hogla	6	Ahmed	Tubular	84001	Work	1410	8	2	2020-06-22
Sala	AA	Hogla	7	Adalluh	Tubular	47100	Work	1130	10	3	2020-06-22
Sala	AA	Hogla	8	Mohmad	Tubular	44619	Work	1200	7	3	2020-06-22
Sala	AA	Hogla	9	Reayidh	Tubular	22608	Work	1100	6	4	2020-06-22
Sala	AA	Hogla	10	Saeed	Tubular	3077	Work	900	7	3	2020-06-22
Saber	bb	Saber	11	Tamer	Tubular	38151	Work	1020	9	3	2020-06-22
Saber	bb	Saber	12	Sadam	Tubular	18840	Work	1030	10	3	2020-06-22
Saber	bb	Saber	13	Name	Tubular	1385	Close	950	7	2	2020-06-22
Saber	bb	Saber	14	Adrees	Tubular	9385	Work	1000	7	3	2020-06-22
Saber	bb	Saber	15	Mosaa	Tubular	21540	Work	1050	7	2	2020-06-22

Figure. Main page of well's report.

Repoting Of State Well

Name of Directorate	Name of Isolation	Wadey	Name Holder	Depth Well	Width Well	Date Insert	State Well	Count the Water of m3	Ratio Presser	Date Reading
Mountains Habashee	Baney Jesus	Althbab	Mohamad	1000	2	2020-04-09	Work	735	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Saeed	1200	1	2020-04-10	Work	351	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Ahmed	800	1	2020-04-28	Work	561	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Mohamad	1000	2	2020-04-09	Work	656	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Saeed	1200	1	2020-04-10	Work	752	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Ahmed	800	1	2020-04-28	Close	960	44	2020-04-09

Figure 5. Report of well's data.

Figure 6 represents the important well's data which updated automatically (see Figure 2) in real time by the data collected by the sensors deployed in the study area.

Directorate name	Isolation name	Village / Valley	Well number	Owner name	Type of well	Currently Available Water	Well condition	Depth of well	Width of well	Warning level	Date of registration
Mountains Habashee	Hathran	The fog	1	Yosof	Tubular	2562	Work	1114	2	5	2020-05-22
Mountains Habashee	Hathran	The fog	2	Corporation	Tubular	65111	Work	1104	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	3	Ghee factory	Tubular	25773	Work	1067	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	4	Grop Haul	Tubular	109423	Work	1082	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	5	General authority	Tubular	77872	Work	1148	10	3	2020-05-22
Sala	AA	Hogla	6	Ahmed	Tubular	84001	Work	1410	8	2	2020-06-22
Sala	AA	Hogla	7	Adalluh	Tubular	47100	Work	1130	10	3	2020-06-22
Sala	AA	Hogla	8	Mohmad	Tubular	44619	Work	1200	7	3	2020-06-22
Sala	AA	Hogla	9	Reayidh	Tubular	22608	Work	1100	6	4	2020-06-22
Sala	AA	Hogla	10	Saeed	Tubular	3077	Work	900	7	3	2020-06-22
Saber	bb	Saber	11	Tamer	Tubular	38151	Work	1020	9	3	2020-06-22
Saber	bb	Saber	12	Sadam	Tubular	18840	Work	1030	10	3	2020-06-22
Saber	bb	Saber	13	Name	Tubular	1385	Close	950	7	2	2020-06-22
Saber	bb	Saber	14	Adrees	Tubular	9385	Work	1000	7	3	2020-06-22
Saber	bb	Saber	15	Mosaa	Tubular	21540	Work	1050	7	2	2020-06-22

Figure 6. Evaluation of well's data.

The monitoring groundwater level has been applied in various period of time (week, month, etc.) to investigate real time data. Figure 7 shows the variation of groundwater level of desired field over time (summer recharge and winter drawdown).

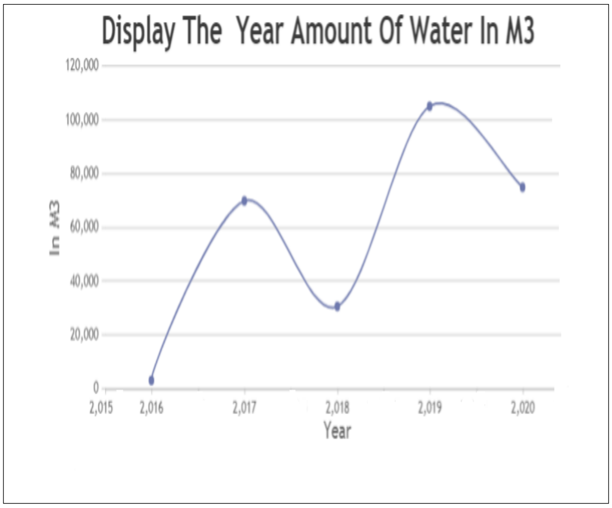

Figure 7. year result of water level.

The current amount of water in the considered zone of individual well as gathering from sensors. Figure 8 indicates the sensors' readings of current amount of water.

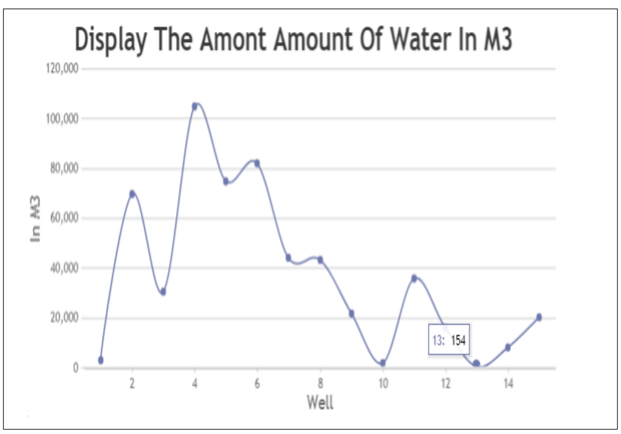

Figure 8. Current amount of water of one zone.

5. Conclusion

In this study, a groundwater level monitoring system is proposed based on a wireless sensor network. The sensors are deployed in the study area to monitor the water level in the individual well. The data collected and send wirelessly to be store and visualize in the cloud. Different performance metrics used to investigate and evaluate the performance of the proposed system, such as and increase the system efficiency such as: environment of web techniques and using the SQL server to build the database. Results show the distribution of data collected from individual well of different zones, and its visualize to end user in real time.

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