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By: LAZREG ZIN ELABDINE

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Drinking Water Management in smart cities

Supervisor : Mr. AZEDDINE ATTIR

Dedication

*I dedicate this humble work
to my dear parents for their great love and sacrifices
to my brothers & sisters
to all my friends especially*

KHALIL

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INTRODUCTION

Water is one of the basic resources needed to human. The ever-increasing demand for water resulting from economic development and population of the world requires constant pursuit of activities related to water management, ensuring the rational development and utilization of water resources, but also the development of devices and networks necessary to raise water supply in sufficient quantity and quality.

As a very important element for the efficient execution of tasks concerning water and wastewater, the operation of water and sewage companies has to be considered. Its functioning is determined by many factors, including: shrinking resources of drinking water and the need to diversify sources of supply, or the search for methods of rational management of current resources in situations of shortages; the extent of distribution of water supply systems especially in urban areas with diverse specifics of fields, buildings, social aspects, etc.

There are numerous challenges in the creation of a city that monitors and integrate all of the city infrastructure and services to leverage the collective intelligence. From technical infrastructure that needs to be put in place, to the adaptation of different systems by citizens, it leaves various technical and non-technical obstacles to be dealt with.

Smart cities in development are now bringing a full infrastructure in many areas (communications, organization, management, etc.) where it works to establish a link between these areas in a smart way based on information and communication technology (ITC).

The Water cycle (water resource, production, distribution, consumption) play a fundamental part of the urban system, influencing each pillar of the urban society and its functionality. The distribution and consumption problems are causing the government too much work.

Smart water management (SWM) approaches seek to promote a sustainable, well-coordinated development and management of water resources through the integration of Information and Communication Technology ICT products, tools and solutions; thus providing the basis for a sustainable approach to water management and consumption.

Harnessing the potential of ICTs in cities using SWM can contribute to overcoming water related socio-economic, cultural and environmental challenges. In our effort to solve some of the challenges, we try to apply SWM techniques in simulation of water distribution in the city of BOUSAADA.

We begin this work with the first chapter by giving a general idea about smart cities and their concepts, while tracking the different steps of their evolution.

In the second chapter, we try to highlight the importance of SWM, its different tools and infrastructure grid, and with that, the different approaches to SWM.

In the third chapter, we try applying the SWM system used in smart cities by making a simulation that solves the different problems of water management in the city of Bousaada.

CHAPTER 1

SMART CITES

Introduction:

In this chapter we give a definition of smart cities and its evolution and different component that make a city a smart city.

1.1 What Is a Smart City?

1.1.1 Smart City Concept:

The concept of smart city is relatively new , There is a wide variety of definitions of what a Smart City could be ,and can be seen as a successor of information city, digital city and sustainable city, However it has been used frequently, especially after 2013, when it exceeded a frequency of citations of other terms including sustainable city [1].

1.1.2 Broad definitions:

- **The UK Department for Business, Innovation and Skills (BIS)** considers smart cities a process rather than a static outcome, in which increased citizen engagement, hard infrastructure, social capital and digital technologies make cities more livable, resilient and better able to respond to challenges.[2]

1.1.3 Data-driven definitions:

- **IBM** defines a smart city as “one that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources”.[3]

- **Cisco** defines smart cities as those who adopt “scalable solutions that take advantage of information and communications technology (ICT) to increase efficiencies, reduce costs, and enhance quality of life”.[4]

A smart city is a framework, predominantly composed of Information and Communication Technologies (ICT), to develop, deploy and promote sustainable development practices to address growing urbanization challenges. A big part of this ICT framework is essentially an intelligent network of connected objects and machines that transmit data using wireless technology and the cloud. Cloud-based "IoT" applications receive, analyze and manage data in real time to help municipalities, enterprises and citizens make better decisions in the moment that improve quality of life[5]. It encompass seven important sectors that need to work in unison to achieve a common goal of making a city livable, sustainable and efficient for its residents. These sectors are Smart Digital Infrastructure , smart mobility, smart energy , smart water ,smart waste management ,smart health ,smart buildings[6].

- The Digital Infrastructure is defined as the ability to store and exchange data through a centralized communication system. Data communication and exchange are all simplified with the right software and hardware equipment. Its help monitoring and analyses different data collect .
- With “smart mobility” we mean the adoption of advanced software solutions that make more accessible and easy to use for citizens all the mobility services within a city or a territory, with a particular emphasis on alternative and sustainable mobility means and modes.
- Smart energy is a cost-effective and sustainable energy system in which renewable energy production, infrastructures, and consumption are integrated and coordinated through energy services, active users, and enabling technologies.
- Smart health is the provision of health services by using the context-aware network and sensing infrastructure of smart cities.
- A smart building is any structure that uses automated processes to automatically control the building's operations including heating, ventilation, air conditioning, lighting, security and other systems.
- Waste management or waste disposal are all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things collection, transport, treatment and disposal of waste together with monitoring and regulation using ICT.

Building smart cities upon the seven sectors is crucial for sustainable global growth, but the financial, logistical and political challenges are enormous. The conversations about growth of smart cities have historically been dominated by large it companies that focus on analyzing "big data" taking a top-down, software-centric approach. However, when it comes to the modernization of hundred-year-old systems like water distribution or the power grid, advanced software and networking capabilities are rarely broad enough in scope to make the necessary impact.

Conversely, a bottom-up approach to smart city development is based on the belief that the rapid migration to cities will tax municipal infrastructures beyond their breaking points. The cities that succeed in transitioning to "smart" operations will be those that improve their critical systems and infrastructure at a fundamental level as well as integrate their systems

through advanced technology. Lastly, smart cities will apply advanced monitoring and analytics to continuously measure and improve performance.

Schneider Electric is working on more than 200 smart city projects around the world, taking this unique infrastructure-first approach, which includes:

- Setting the vision and roadmap for an efficient, livable and sustainable city
- Combining best-in-class hardware and software to improve operating systems
- Bringing in integration for city-wide operational and informational efficiency
- Adding innovation as a foundational element of planning and operations [7].

Schneider Electric SE is a European multinational corporation that specializes in energy management, automation solutions, spanning hardware, software, and services.

One of its branches is in Algeria.

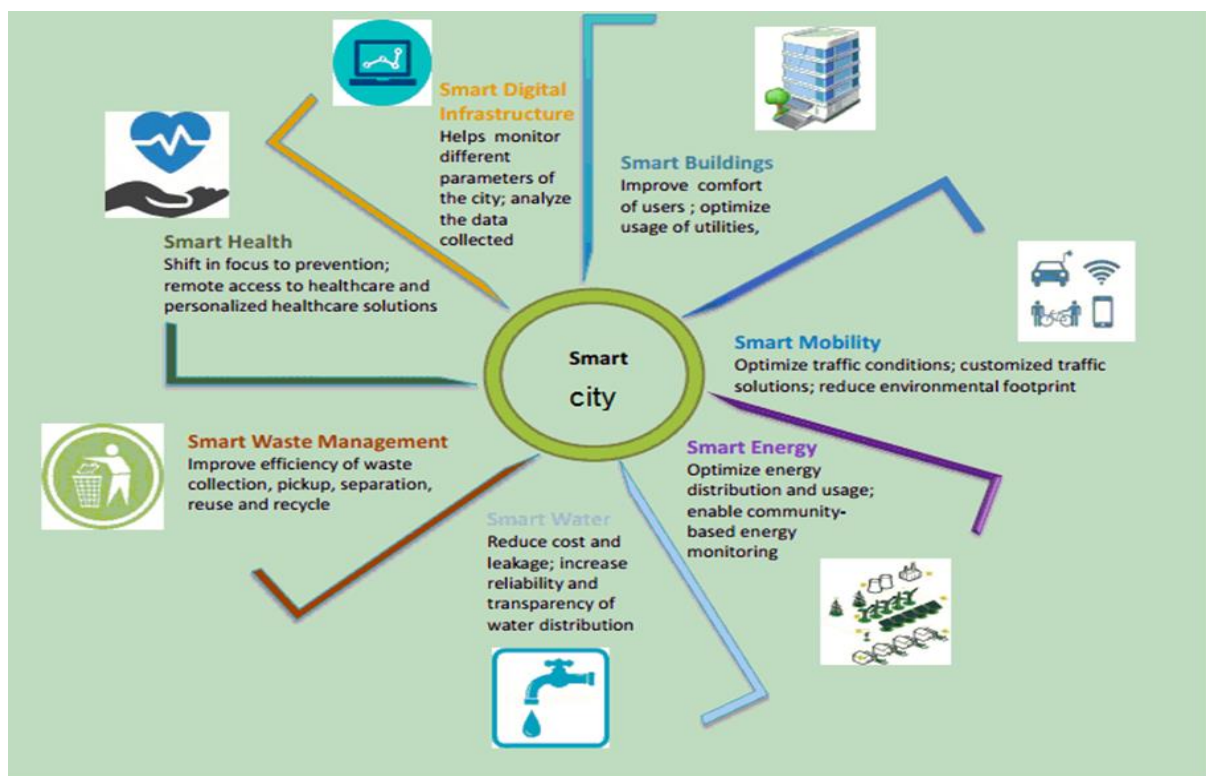


Fig1.1: present of smart city component

2 The Smart City Evolution

The smart city concept started appearing in time with different terms and perspectives as a means to define urban technological evolution. More specifically, smart city was not the

initial term that was used by scholars. Instead, scholars in late 1990s started discussing about city and ICT from different perspectives and with the use of different terms, in their attempts to describe ICT project initiation within [Fig 1.2]

First evidence regarding smart city appears in literature in 1997 (Graham and Aurigi 1997), where it is claimed that over 2000 virtual cities and urban web pages existed in 1997, which introduced the term web or virtual city in an attempt to describe local ICT network initiatives, which enabled the development of local cyber-based (virtual) communities (decentralized, interactive, one-to-one and one-to-many media networks). Virtual cities were based on the World Wide Web (WWW) and they operated as electronic analogies for the real, material, urban areas that host them. [8]

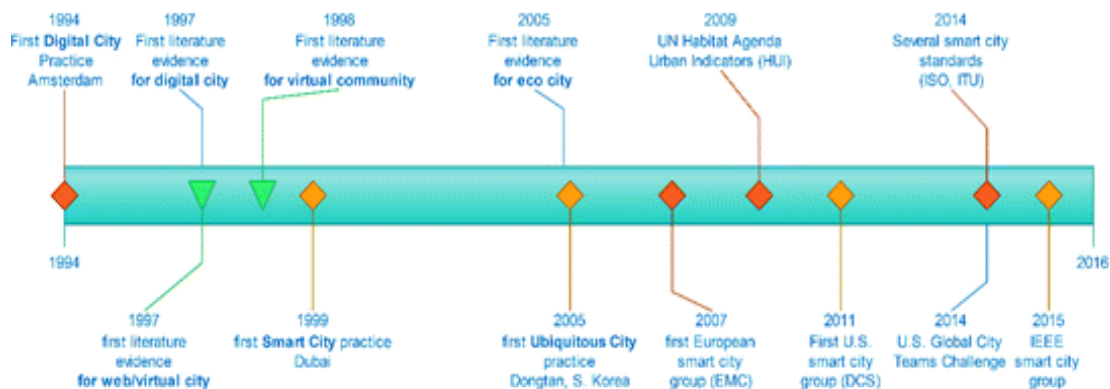


Fig 1.2 :Smart city evolution timeline

There are a number of cities actively pursuing a smart city strategy.

Example:

Amsterdam :

The Amsterdam smart city initiative which began in 2009 currently includes 170+ projects collaboratively developed by local residents, government and businesses [9]. These projects run on an interconnected platform through wireless devices to enhance the city's real time decision making abilities. The city of Amsterdam claims the purpose of the projects is to reduce traffic, save energy and improve public safety. To promote efforts from local residents, the city runs the Amsterdam smart city challenge annually, accepting proposals for applications and developments that fit within the city's framework. An example of a resident developed app is "Mobypark"[Fig 1.3], which allows owners of parking spaces to rent them out to people for a fee. The data generated from this app can then be used by the

city to determine parking demand and traffic flows in Amsterdam. A number of homes have also been provided with smart energy meters, with incentives provided to those that actively reduce energy consumption [10]. Other initiatives include flexible street lighting (smart lighting)[Fig 1.4] which allows municipalities to control the brightness of street lights, and smart traffic management where traffic is monitored in real time by the city and information about current travel time on certain roads is broadcast to allow motorists to determine the best routes to take .

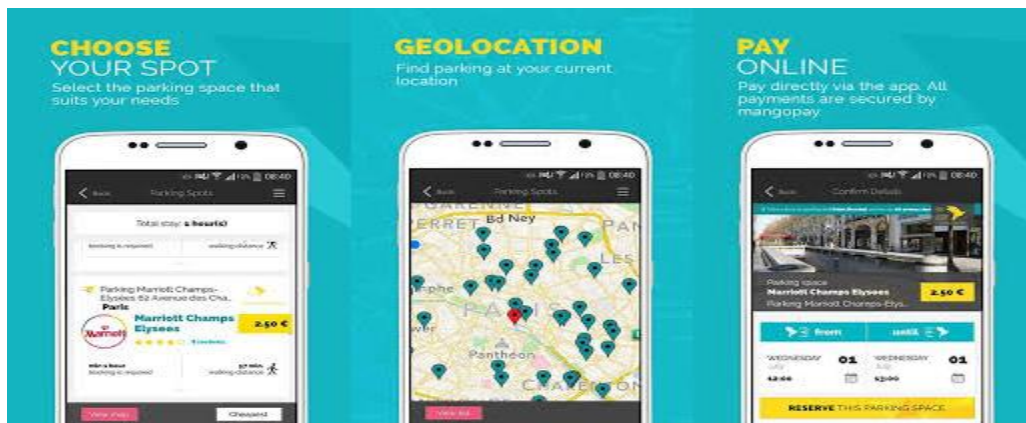


Fig 1.3 : MobyPark app

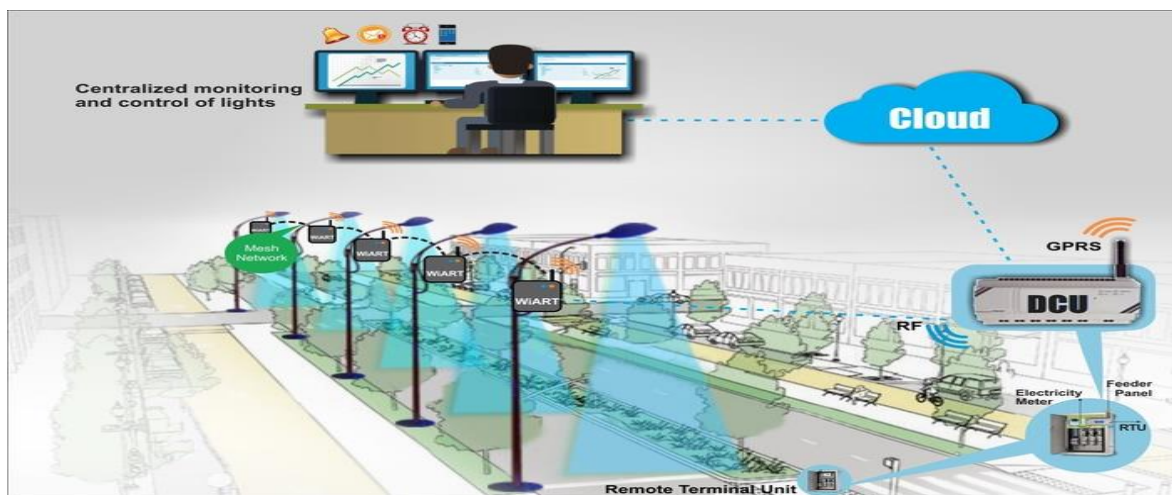


Fig 1.4 : smart street lighting

Conclusion:

There is a lot of countries take the smarting urban areas as the future solution to all challenges that they facing. Because smart cities give a better control of things, and make living a lot easier. Due to the options its gives in different areas and field in the next chapter will present one of important files smart water management .

CHAPTER 2

SMART WATER MANEGEMANT

Introduction :

In this chapter we will represent the impact of water management in smart way effect the smart cities, and the tools used in the SWM and smart water grid that build the water infrastructure .

1 WHY SMART WATER MANEGEMANT ?

Water is a fugitive resource, flowing through space and time across landscapes and through economies. All benefit from it, but few understand how it is actually managed. The management of water is not merely a technical issue; it requires a mix of measures including changes in policies, prices and other incentives, as well as infrastructure and physical installations. Integrated water resources management (IWRM) focuses on the necessary integration of water management across sectors, policies and institutions.

Over the next three decades, urban populations will continue to grow, as will incomes and water usage per capita, against a backdrop of a changing climate. By 2050, the UN forecasts that more than six billion people will be living in cities and global water demand will be about 55 per cent higher than today. These factors could disrupt two of the essential services that are required for cities to flourish: the availability of affordable, safe, clean water and sewerage services.[11].

In Asia, water loss costs about \$ 5 billion in 10 years. According to the Korea Study Bureau, approximately 10 million cubic meters of water per year is lost due to leakage in the pipes. .[12]

As much research shows, water infrastructure must be upgraded and water management must improved .

2 Smart cities / smart water management

One of a city's most important pieces of critical infrastructure is its water system. With populations in cities growing, it is inevitable that water consumption will grow as well. The term "smart water" points to water and wastewater infrastructure that ensures this precious resource - and the energy used to transport it - is managed effectively. A smart water system is designed to gather meaningful and actionable data about the flow, pressure and distribution of a city's water. Further, it is critical that the consumption and forecasting of water use is accurate[13].

Water management is closely associated with water resource development and environmental protection, and it entails proper management of the demand for public services and cost effectiveness. Recognizing the challenges faced by the water sector, stakeholders from academia, corporations and the ICT sector have developed water intelligence tools that use ICTs to alleviate global water issues. The role played by smart water systems in optimizing the efficiency, effectiveness and flexibility of water and wastewater infrastructure assets and their management constitutes a topic of increasing attention..

ICTs offer valuable opportunities to improve the productivity and efficiency within the water sector, with the aim of contributing to the sustainability of the resource. These technologies allow the continuous monitoring of water resources, providing real-time monitoring and measuring, making improvements in modelling and problem diagnosis, thus enabling proper maintenance and optimization of all aspects of the water network.

The increasing availability of more intelligent, ICT-enabled means to manage and protect the planet's water resources has led to the development of smart water management (SWM). The SWM approach promotes the sustainable consumption of water resources through co-ordinated water management, by integrating ICT products, solutions and systems, aimed at maximizing the socio-economic welfare of a society without compromising the environment. SWM can be applied to multiple sectors (e.g. industries, agriculture) and urban environments[14].

2.1-Definition: Smart water management (SWM):

The term of smart water management, means uses Information and Communication Technology (ICT) and real-time data and responses as an integral part of the solution for water management challenges.

2.2-SWM TOOLS:

SWM tools can be categorized in the seven main areas listed below. It should be noted that the examples provided are not limited to these areas, but may overlap several others, as seen in [Fig 2.1].

1. Data acquisition and integration (e.g. sensor networks, smart pipes, smart metres).
2. Data dissemination (e.g. radio transmitters, wireless fidelity (WiFi), Internet).
3. Modelling and analytics (e.g. geographic information system (GIS), Mike Urban, assessing and improving sustainability of urban water resources and systems (AISUWRS), and urban groundwater (UGROW).
4. Data processing and storage (e.g. software as a service (SaaS), cloud computing).
5. Management and control (e.g. supervisory control and data acquisition (SCADA, WINCC), optimization tools).
6. Visualization and decision support (e.g. web-based communication and information systems tools).
7. Restitution of data and information to cities' technical services and to the end users e.g. Tools for sharing information on water and on services).[15]

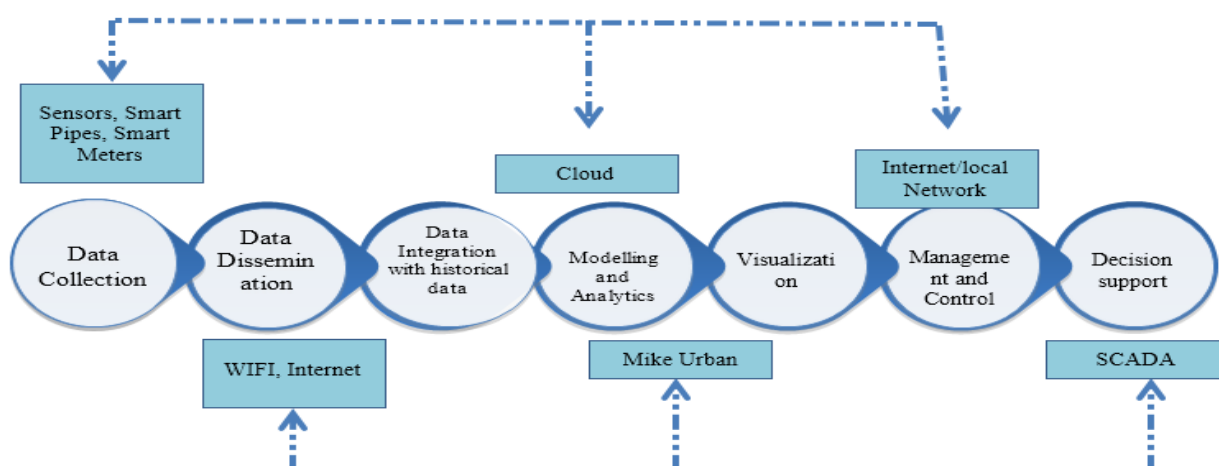


FIG 2.1 : Schematic representation of smart water management technologies and tools.

As illustrated in [Fig 2.1], SWM technologies often overlap a series of functionalities that are key for the effective operation of urban water systems. The following section will explore in more detail the role of each of these technologies, and their contribution to SWM.

2.3-SWM technologies:

Smart water Management technologies are currently applied to many different areas of water management, as illustrated in [Fig 2.2].



Fig 2.2 : Current implementation of smart water Management technologies and tools

When applied Smart water Management technologies to cities, the availability of reliable data to enhance operations can improve decision-making at multiple levels. Many innovative ICT tools have been developed in support of next-generation urban water infrastructure systems, helping to improve performance, increase efficiency, and reduce costs, decrease redundancy, and lower environmental impacts, among others. Some of these smart technologies are explained below:

2.3.1-Smart pipes and sensor networks

Smart pipes incorporate multifunctional sensors that can sense strain, temperature and pressure anomalies, as well as measure water flow and quality during service, to provide operators with continuous monitoring and inspection features, while assuring safer water supply distribution. Connecting smart pipes with a wireless processor and antenna enables

data to be transferred directly to a command centre, providing water managers with the tools needed to detect and locate potential leaks in real time [Fig 2.3].

Smart pipes were initially developed for the transportation of oil, gas and hazardous liquids. Over the years, their applicability to water networks has slowly been realized. New research and development in prototypes for water distribution are needed to continue to advance public water supply systems. [16]

Wireless sensor networks provide the technology for cities to more accurately monitor, and sometimes control, their water supply systems intricately using different parameters. Examples include sensors with the ability to analyse the acoustic signature of a pipe or to monitor soil moisture and detect leaks (e.g. if the ground is absorbing water, it could be an indication of a pipe leak; if the minimum daily noise is increasing it also means that a small leak was recently created). Many ICT companies are developing a wide range of sensors specifically designed for water networks. The system reports pipe flow measurement data with pressure and acoustic measurement combines this information to GIS data and sends automatic alerts to identify the location of possible leaks, thus allowing the prioritization of repair work. Such sensors are the core of these systems, which perform the online measurement of the fundamental parameters of water quality including pH.[17]

Major tasks for smart sensor networks in water quality monitoring. Integrating smart pipes and sensors within the urban system enables key functions such as the detection of events based on the monitoring of flow rate, pipe pressure, stagnant points, slow-flow sections, pipe leakage, backflow, and water quality to be monitored, which constitute data needed to optimize the operation of current networks.

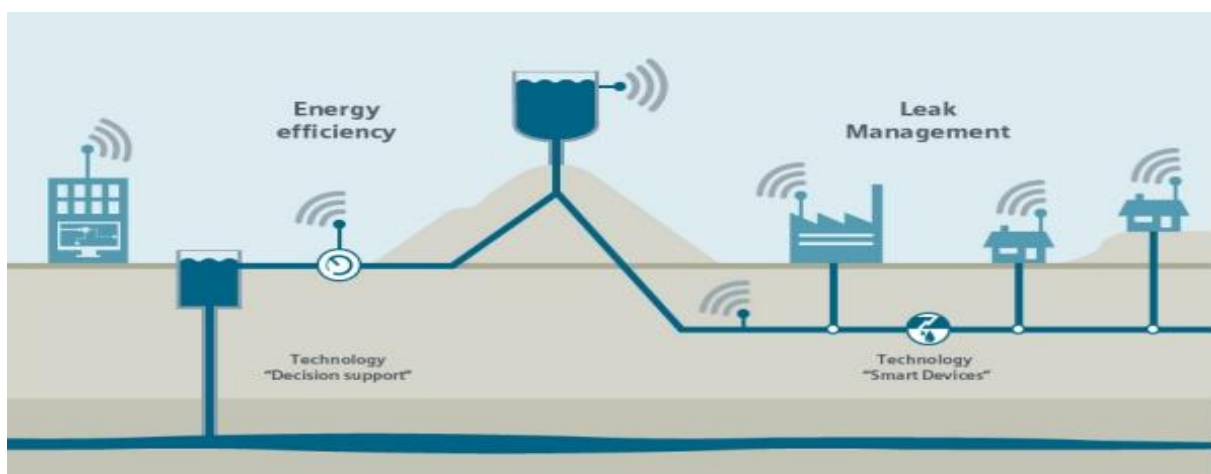


Fig 2.3 :smart pipes and sensors

2.3.2-Smart metering:

Smart metres are electronic devices with advanced metering infrastructure (AMI) that supports on-line measuring of electric, heat, gas, and water consumption.. In the case of water consumption, smart metres typically consist of an embedded controller that interfaces with a metering sensor, a wireless transmitter, as well as communication extension and a 10-to-15-years-lifetime battery, as there is no mains power supply available for water meters. The metres are connected to a network of data logger which allows for the continuous monitoring of water consumption of a city, a building, a business or a home. The innovation of smart metres enables a two-way communication when required between the metre and a central system by transmitting data, which can be done through different channels (e.g. power line, Internet, telephone).

Smart metres typically collect consumption data, and then transmit this data to a gateway that interfaces with the local area network (LAN), home area network (HAN) and wide area network (WAN). The LAN consists of the metrology or measurement function of the metre, while the HAN is connected to the customers' network. Due to the display functions of HAN, it easily allows accessibility to consumption data through a user-friendly interface, allowing customers to compare and track their water consumption. As HAN functions are energy consuming those can be replaced by a web access to Home Data and collected via the LAN and the WAN. WAN is managed by the utilities and allows them to track, monitor and bill consumption.

The deployment of smart metres within an urban infrastructure enables remote accessibility of consumption data, which improves metre reading and billing, detection of leaks, illegal connections and tamper alerts, and can also enhance the identification of peak demand mainly for energy. Customer and provider relationships are improved through increased communication, utilities can improve their tariffs policies and consumers can be equipped with options like on-line alarms in case of leak or suspicious consumption, or the possibility to change payment methods (e.g. prepaid or postpaid).

Smart metering also allows water utilities to provide clear water consumption information which can help customers to track and control their water usage, and identify immediate savings on their bills, thus enabling better distribution network and consumption planning due to its real-time monitoring capabilities. [Fig 2.4] illustrates an example of AMI infrastructure and SWM capabilities.

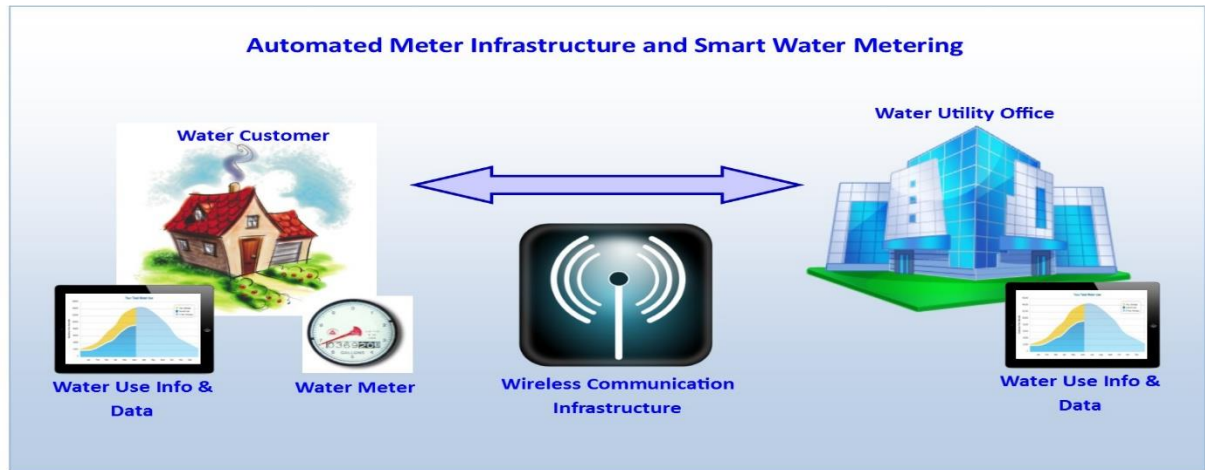


Fig 2.4 – Smart meter technologies



Fig 2.5 – smart meter

2.3.3-Communication modems :

Communication solutions include Bluetooth, Wireless M-Bus communication, global system for mobile communications/general packet radio service (GSM/GPRS), and Ethernet, among others [Fig 2.6]. These solutions allow remote reading of sensors and metres by the direct transfer of real-time or time-stamped data to the central management system of the utility or water authority. The data is then made available online for customer information system (CIS), cloud computing or supervision and data management tools, supporting improved decision-making within the system. Such communication devices incorporated with smart metres/sensors can also provide alerts to authorities (e.g. reverse flow, leak alert, fraud alarm, and battery levels, water quality alarms). Most of these types of communication solutions ensure spatial redundancy and enable a wide range of coverage between distant buildings, housing estates, and other districts. In the traditional collection systems, considerable amounts of time would have been wasted finding and measuring points, especially in remote locations.[14]



Fig 2.6 : smart modems

2.3.4-Cloud computing

Cloud computing uses an external computing power ability which is outside the boundary of a user's own infrastructure, to run programs or applications. Cloud environments typically

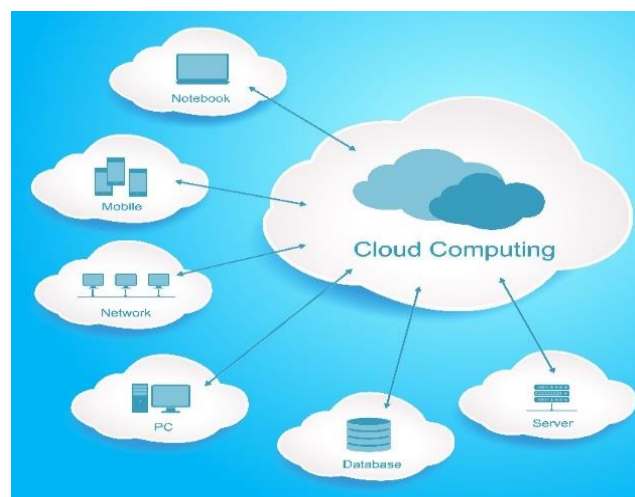


Fig 2.7 : cloud computing

enable the following functionalities: monitor and manage computing without human involvement, broad network access to allow computing services to be delivered, access over several networks and heterogeneous devices, technologic ability to scale up or down computational resources swiftly and as needed, ability to share across multiple applications, as well as to track applications/tenants for billing purposes.

Cloud systems in urban settings also allow high efficiency and high utilization of pooled resources for a better balance of workload and computation through multiple applications, providing urban water managers with a wide range of possibilities in computer modelling and data storage. Urban flood management is another area where cloud computing is increasingly use. [18]

2.3.5-Supervisory control and data acquisition (SCADA/WINCC)

When incorporated into water management systems, supervisory control and data acquisition (SCADA) [Fig 2.8] are computer-controlled systems that contain a large variety of communication systems, allowing to monitor and control water treatment and distribution. The system allows for supervision through data acquisition and management, and has the ability to process and send commands within the system. The communication system may involve radio, direct wired connections or telemetry.

Utilities have been using SCADA systems managing real-time alarms and efficiently operate plants and networks. In some case, SCADA systems are going beyond their native functionalities by proposition optional modules on modelling or optimization. Globally speaking SCADA systems have contributed to reduce the operating costs of utilities, and have improved water distribution to households, businesses and industry. The monitoring and control functionalities of SCADA systems can help utilities to protect their infrastructure and prevent severe degradation. The implementation of SCADA has been associated to 30% savings on energy used to manage water systems, 20% reduction on water loss and 20% reduction in disruption . Usage of SCADA as part of urban systems can also enhance disaster preparedness through storm water management, as well as support the remote operation and monitoring of major dams and weirs. [14]

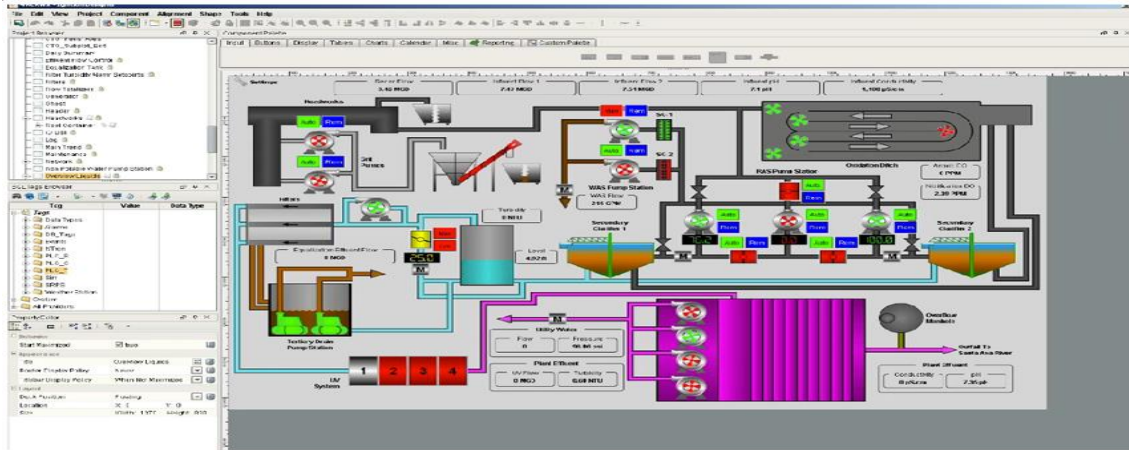


Fig 2.8 : Example of SCADA software, Western Municipal Water District (WMWD), California

3-Smart water grid: the water management platform

Current water network structures are based on large and centralized systems in which the management options are limited. The major limitations of these systems are: low operating efficiency due to the imbalance between the supply of and demand for fresh water, loss and/or contamination of the supply water, high energy requirements for production and transportation of the supply water, high treatment cost and/or low treatment efficiency of both supply water and waste water due to the fixed treatment processes, and lack of integration of alternative water sources. In order to overcome these limitations, a new water management scheme that can make real-time management possible is Required [19]. [Fig 2.9]

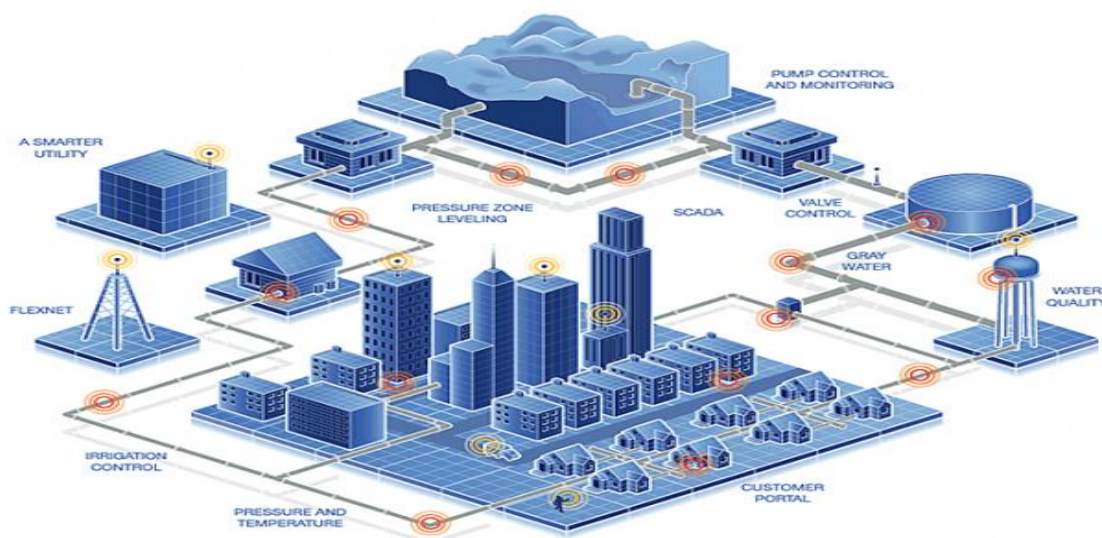


Fig 2.9 : smart water grid

3.1 Methodology

3.1.1 Platforms

Platforms are essential building blocks and the skeletons of the new SWG-based water infrastructure, as the entire system will be formed on these platforms. There are two main platforms established in the new water management infrastructure: the water grid platform and the ICT platform.

3.1.2 Water grid platform

The water grid platform divides the urban macro water grid into smaller water-grids in order to establish a stable decentralization plan, while installing a central management and a storage structure. Each water-grid is comprised of a fresh water source, a treatment structure, a fresh water reservoir, and a residential or industrial/irrigational area. Originally it's the old platform. Bi-directional water flow between the freshwater reservoirs and central reservoir allows the management scheme to allocate water from one water grid to the other one without disturbing the urban water cycle and causing public annoyance.

3.1.3 ICT platform

The ICT platform is constructed on the main water grid platform [Fig.2.10]. Bi-directional data flow between individual water network elements and between these elements and the central management scheme creates an effective management structure. When no disturbance is present, each grid can act as an individual water network with no central management required. However, when there is a disturbance in one or more of the grids, the central management can take over the control and make adjustments in the whole system.

In this system, the ICT platform enables the data flow from numerous sensors to both the individual grids and the central management structure. Pressure sensors for burst (or leak) monitoring and biosensors for water quality monitoring are examples of these sensors. The ICT platform also combines the power and water grid data in order to increase the efficiencies in both grids and to minimize the energy consumption.[19]

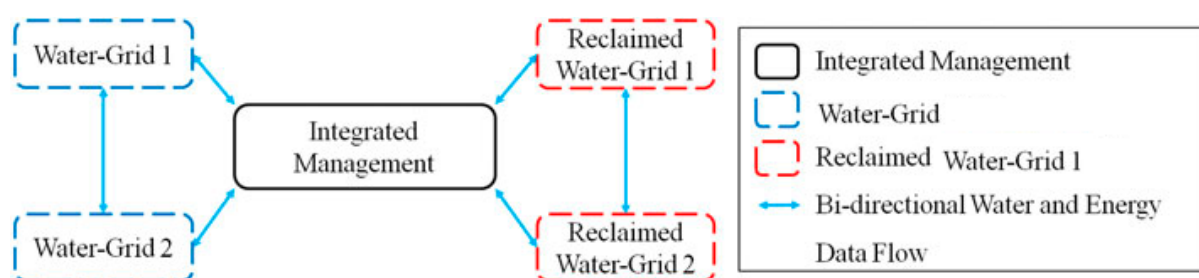


Fig 2.10 : Bi-directional data flow for water and energy within the water grids and between grids and the central management structure.

3.1.4 Intelligent network

The intelligent network structure consists of two parts: self-diagnosing sensors and ICT based cooperation network. The integration of standardized sensor systems for water quality, quantity, and pressure then can be used to create a sustainable data flow structure in the water network infrastructure. In this system, auto-diagnosis enabled digital smart telemeters, which have low power consumption and can work both online and offline, enhance the management abilities in both the water grid and ICT platform.

In order to establish an ICT network, sensor interface technologies and smart node networks are required that have open code software(SCADA/WINCC), protocols, etc.

The ICT network can then establish a smarter water management scheme based on proactive asset management, rapid real-time decision-making, and system-level decision-making.[19]

4 Global trends toward SWG technologies

4.1 smart cities/companies

Over the last two decades, a number of natural events, forced governments and water companies to develop preventive measures for water management and security. Globally, there have been several different approaches used to secure the water quality and quantity required for urban areas.

However, to date, two governments have successfully established new water management infrastructures. One is the South East Queensland (SEQ) Water Grid from Australia, and the other is the Water Supply Network Department (PUB) from Singapore. These two governmental bodies have become the leading authorities on this topic in the world.

There are also numbers of new projects and proposals, some funded by governments, that will be applied to megacities pending their degree of success.

One such project is the SWG project funded by Korea Ministry of Land, Infrastructure and Transport. The SWG methodology mentioned above is the core technology of this project. Another interesting project proposal is the National Smart Water Grid (NSWG) from the USA. Even though there has not been an initiative action for this project, it is still a sophisticated solution to alleviating water scarcity problems in the midwest USA.[20]

4.1.1 SEQ water grid, Australia

During 2007 and 2008, SEQ faced the worst droughts on record, when the combined water levels in three major dams (Wivenhoe, Somerset, and North Pine) dropped to less than 17% capacity. The SEQ Water Grid was developed and delivered during this time as the largest urban water security response in Australia.

The SEQ water grid is an integrated system that focuses on the security and management of SEQ's water supplies. In brief, the SEQ infrastructure is comprised of treatment facilities and two-way pipelines that make bi-directional water movement possible. One of the major changes that the SEQ water grid introduced was the integration of climate-resilient water sources (desalination and purified recycled water) to the system, in addition to new water sources such as rainwater. They also integrated water demand forecasting into their management structure in order to avoid future water scarcity issues.[21]

4.1.2 EU Urban Water project

UrbanWater is a collaborative ICT project co-funded under the 7th Framework Programme of the European Commission. The project is expected to be completed in 2015. It seeks to create an intelligent web-based urban water management system for effective urban water management. The platform will incorporate advanced metering solutions and real-time consumption data to equip water utilities with the information necessary for proper decision-making.

By integrating water availability estimations based on weather prediction and surface water reserves data, demand estimations based on household consumption data and consumption patterns and models, the water distribution network data, as well as automatic billing capabilities including adaptive pricing and customer engagement tools and using secure and cloud-based data management, both utilities and customers alike will be able to obtain the right information to effect change in consumption patterns in urban areas. [22]

4.1.3 SWG research, Korea

Korea has been taking the water scarcity issue seriously as it has faced severe droughts over the last couple of decades due to climate change and the exponential growth in city populations. For example, the Gol-ji River in Taebaek almost dried out in 2009, and the government was forced to limit water consumption during day times. Based on the need for a stable water supply, Korea is planning to spend more than 10 billion USD by 2025 in order to expand water facilities, repair decrepit facilities, and stabilize the facilities, and increase the research and development (R&D) outcomes. Around 800 million USD will be spent on R&D, and the outcomes from these studies will be applied to cities and watersheds. To perform SWG research in Korea, two main steps are required to extend the core technology from pure research to applications in industry :

1-Smart water grid

- (a) Component technology development.
- (b) Optimized parts and materials development.
- (c) Development of ICT-based integrated management system for SWG.

2-Construction of water grid test bed

4.1.5 Delft-FEWS and Hollands Delta Regional Water Authority, Netherlands (pilot project)

In the Netherlands, extensive sewer networks are linked with SCADA. However, systems are not linked to Wastewater Treatment Plants (WWTPs) nor are they linked together, as each municipality is responsible for maintenance and operation within its boundaries. The system is vulnerable to storm events which sometime results in the contamination of surface waters. The pilot project was supported by grants from Agentschap NL, and investigated the possibility of optimizing the sewage flow through the entire system using an automated centralized control of the system: by linking the SCADA systems of the regional water authority Hollandse Delta, and the WWTPs of five municipalities and using the dynamic modelling component of Delft-FEWS. Delft-FEWS is a real-time operation water management and forecasting software. Data was collected from each SCADA system and fed to Delft-FEWS, where a real time control (RT C) plug-in calculates the optimal pump settings. The settings calculated from Delft-FEWS were then sent back to the SCADA

systems to control the sewer pumps . The project demonstrated how SCADA systems can be easily converted to centrally controlled operating systems. It is still working as an operational system, with plans to expand its functionality to other municipalities.

Conclusion:

SWM technology is based on the creation of ICT integrated water management solutions to guarantee the security of water quantity and the safety of water quality. Smart water management (SWM) can play a key role in the transformation of cities of developed and developing countries into smart and sustainable cities. In the next chapter, we will see the effect of SWM by simulate a solution of water distribution problems in one of Algeria cities Bousaada city.

CHAPTER 3 :
THE SMART WATER SIMULATION

Introduction :

In this chapter we will see one of non_smart city water distribution problem and make a simulation to a proposed system to solve the problem.

the water management in Algeria is ignored , it cost the government a lot of money every year . we took our hometown Bousaada city as case for study, and try to make a system to manage the water comparable to water management in smart cities.

1 Bousaada, a case for study

Water is distributed in the city of Bousaada once a week for a period of 4 to 3 hours.

The problem is that the water reaches some houses more than others in the same street or neighborhood.

Causes of the problem:

- Using water pumps.
- Water leakage in the main pipe or sub-pipe.
- Problem in the pipe due to accumulated lime.

1.1 suggested solutions:

1-Divide the water equally for all houses by controlling the amount of water directed to each house.

"Considering the number of individuals per household, the distribution of water equally is unsatisfactory."

2-Dividing water for houses according to the population of the house and the number of tanks in the house.

1.2 Approved system, to achieve satisfactory water distribution :

1.2.1 Proposed system

1- Control the flow of water, adjust the flow of water and make all houses have the same flow even if they have a pump, by controlling an automatic faucet.

For example: 30 liters / min per house.

2- Control the flow of water to homes by semi-automatic system, by the water supplier When all the tanks are filled in the house, the flow of water decreases by a certain percentage or stops completely, to allow the other houses to fill the tanks.

When the tanks are full, the flow rate decreases by 80% to 90% or stops. After all houses have enough water, the water automatically flows into the homes. If the specified period does not expire.

The purpose of this system:

the general purpose of this work is to Approaching justice among consumers in the amount of water direct to each house.

we made researches in the field to make this system, by asking my hometown water company of how they distribute the water and which system they use.

We've been in much difficulties ,because to make this system we need an experience on the field and must know every part of the system how its work. And most of the information in the internet must pay to get it because this subject is new in the world.

2 SYSTEM DESIGN:

This SWM system is based on

2.1Hardware:

- 1- Intelligent water meter.

Intelligent water meter can send data to the supervisor see (chapter 2, 2.3.2-Smart metering)

- 2- Water flow sensor.

a devices can detect the rate of water flow see (chapter2 , 2.3.1-Smart pipes and sensor networks)

- 3- electric valves :

electric valves job is to open the flow or closet from distance by the supervisor .



Fig 3.1 : valve electric

- 4- A Programmable Logic Controller, or PLC, is a ruggedized computer used for industrial automation. These controllers can automate a specific process, machine function, or even an entire production line [Fig 3.2].
- 5- A communication modems :see (chapter 2 , 2.3.3)



Fig 3.2 : PLC's job

The architecture of the proposed system is organized on streets, neighborhoods or complex buildings and is composed from cabinets placed in field. Every cabinet contains a PLC and a switch that are connected in an Industrial Ethernet city network. The PLC has an Ethernet port or an extension Ethernet module attached for connection with the switch.[23]

The topology of the communication nodes is same as actually distribution nodes street nodes, big consumer's nodes, neighborhood nodes and city main nodes. Big cities can be supplied from multiple plants, so the distribution is on plant zones. All the nodes are bi-directional, the buildings communicate to the supplier plants the energy power or other resource quantity that they will need and wait for confirmation before starting the consumers. Also the supplier plants can communicate to the buildings that they encounter problems in supplying. The buildings will communicate back how much they can reduce the resource consumption and waits for stopping confirmation. The basic topology of the proposed system is presented in [Fig 3.3][Fig 3.4].

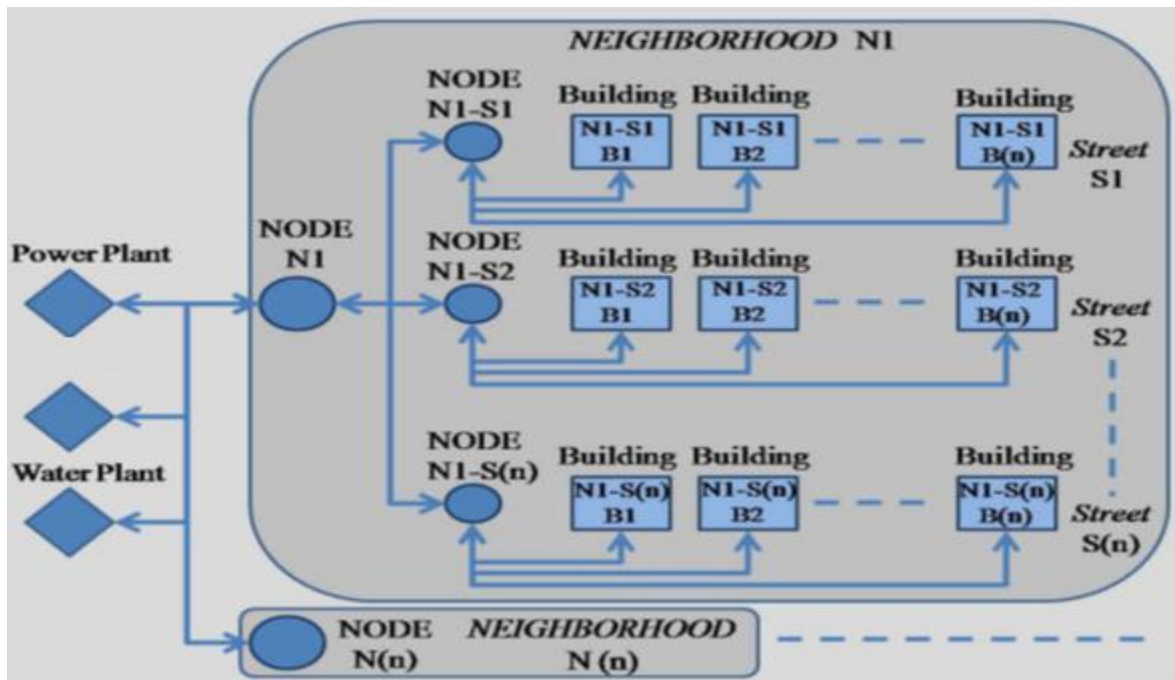


Fig 3.3 : Basic topology of the SWM

The nodes are cabinets.

The Node 1 connect to Nodes N1-S(n) by Ethernet . and controlled by supervisor .nodes N-S connect to building the building have (Intelligent water meter ,Water flow sensor electric valves).

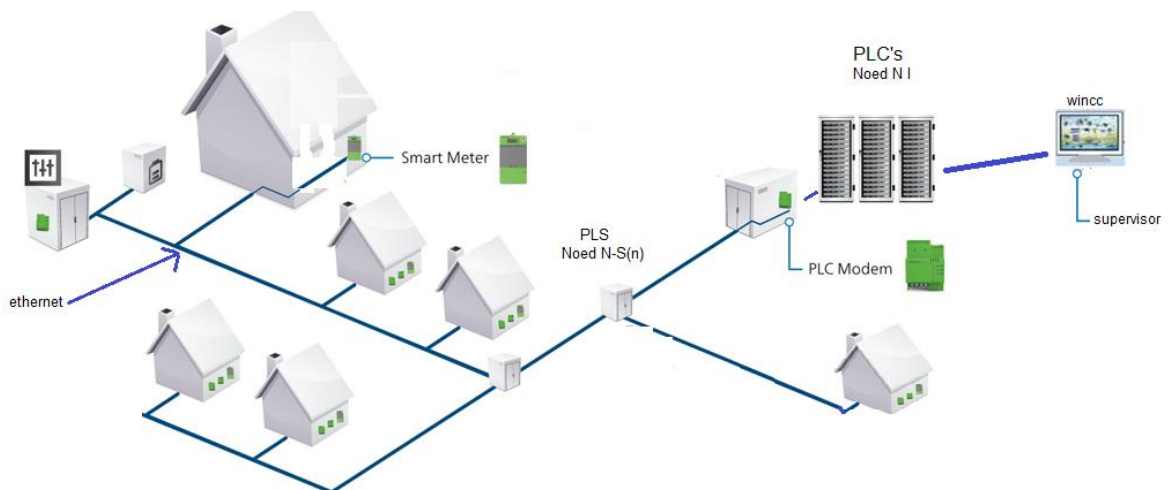


Fig 3.4 : plc's & (os) connecting by Ethernet.

A SWM system can be considered as divided on two main levels. The field level where are the PLC's, PLC's extension modules,(sensors and actuators...etc) that interact directly

with the building physical installations and equipment's. And the management level, as second level, where are placed the supervisory control and data acquisition (WINCC) .

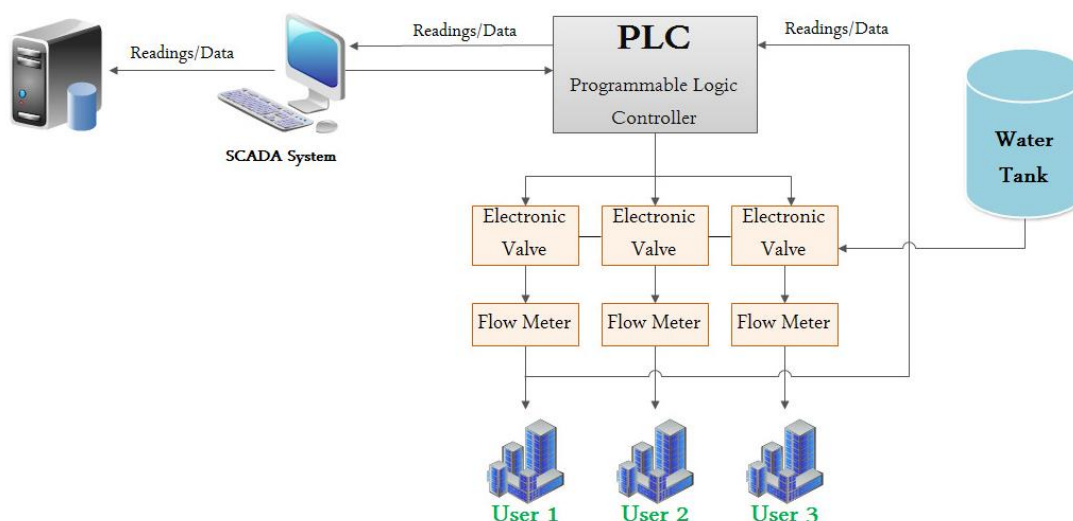


Fig 3.5 System Architecture

2.2 SOFTWARE :

For system monitoring we use the SIMATIC WinCC 7.0 application [Fig3.6], that is SIEMENS HMI software usually used in industrial installations that runs on Windows operating systems and composed from two software parts: the configuration software and the runtime software. After the software is properly configured, all the building sensors and actuators connected to the PLC's are real-time transmitted through the Industrial Ethernet Network to the servers. The operator to monitor and set the process parameters uses the Runtime software. This software can execute tasks like: reading of the data stored in the control system database, displaying of the screens, communication with the building automation systems, archiving of the current runtime data, such as process values and alarm events, current state of the process. "All the SIMATIC WinCC 7.0 functions and settings can be found in SIEMENS AG (2008)".[24]

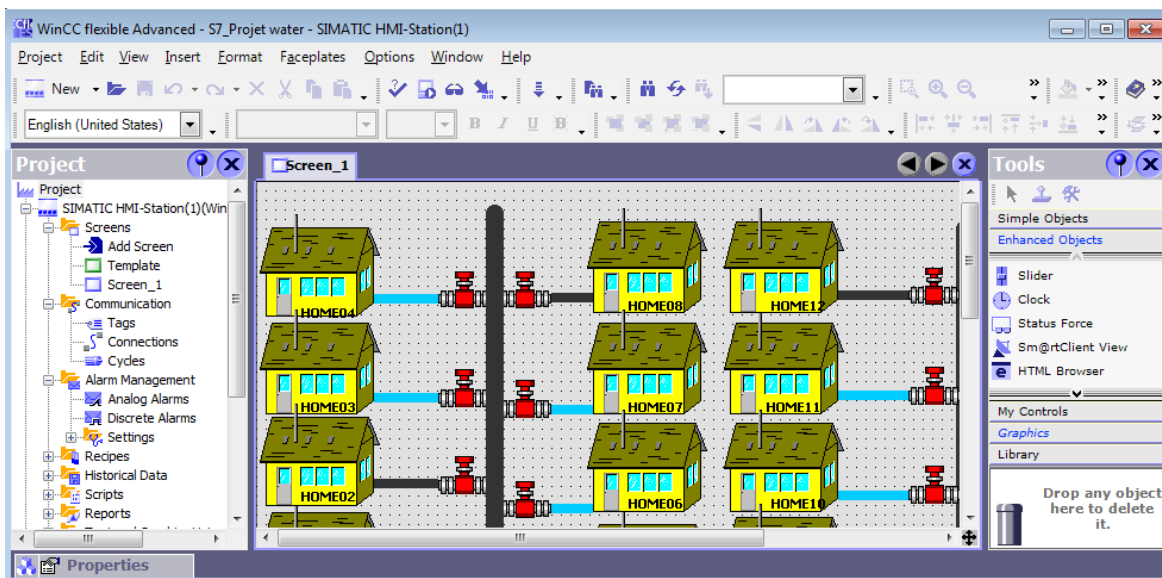


Fig 3.6: WINCC main screen .

to configure and programming The PLC's ,we use SIMATIC STEP 7[Fig 3.7], a standard SIEMENS software package, part of the SIMATIC industry software.

SIMATIC STEP 7 provides powerful programming editors for programming the SIMATIC S7 controllers.

Ladder logic (LAD) and function block diagram (FBD) languages are available for all controllers.

Ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. Ladder logic is used to develop software for programmable logic controllers (PLCs) used in industrial control applications.[25]

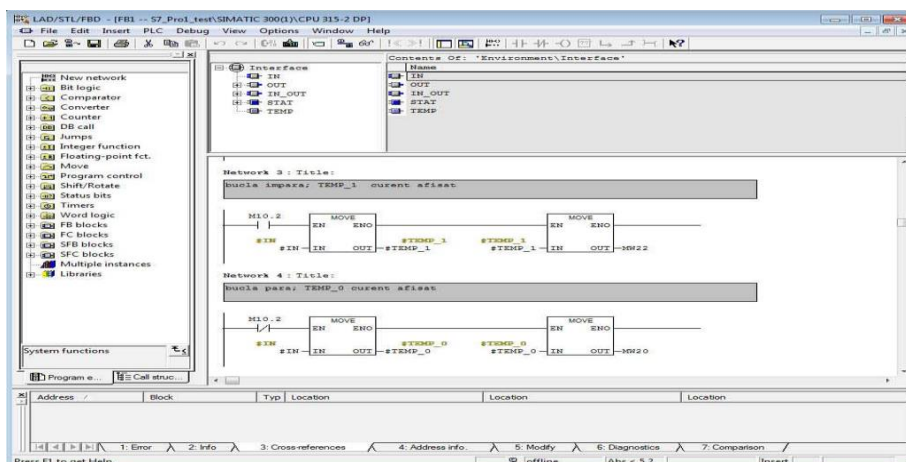


Fig 3.7:STEP 7 programming example.

3-The system simulation

To create a simulation to the system, we used WINCC flexible V5.6 [Fig3.6] and SIMATIC STEP7[fig 3.7] and for programming LAD programming language .we apply the system in quarter of the city.

The system works, with automatic system and manual system, controls electronic valves, And the main water supply engines, and the amount of water directed to each house can be controlled [Fig 3.8].

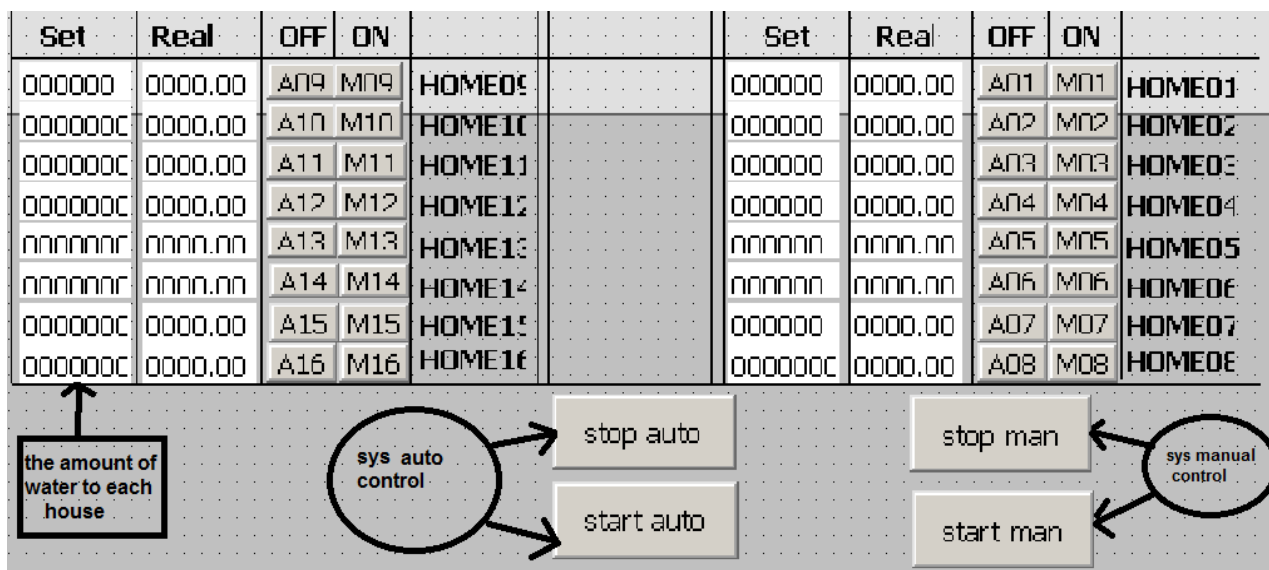


Fig 3.8 : part of the sys on WINCC .

-The "on" and "off" button works to stop or open the water flow to the house , but the "on" button don't work unless the system manual open.

- Each system work alone , it can control only the flow of water .

System auto : base on the total time (TT) that set in the system and amount of water that set on each house . the total time and amount of water sets manual , based on the data collected

After open the IHM (WinCC) we have two options :

3.1-System auto:

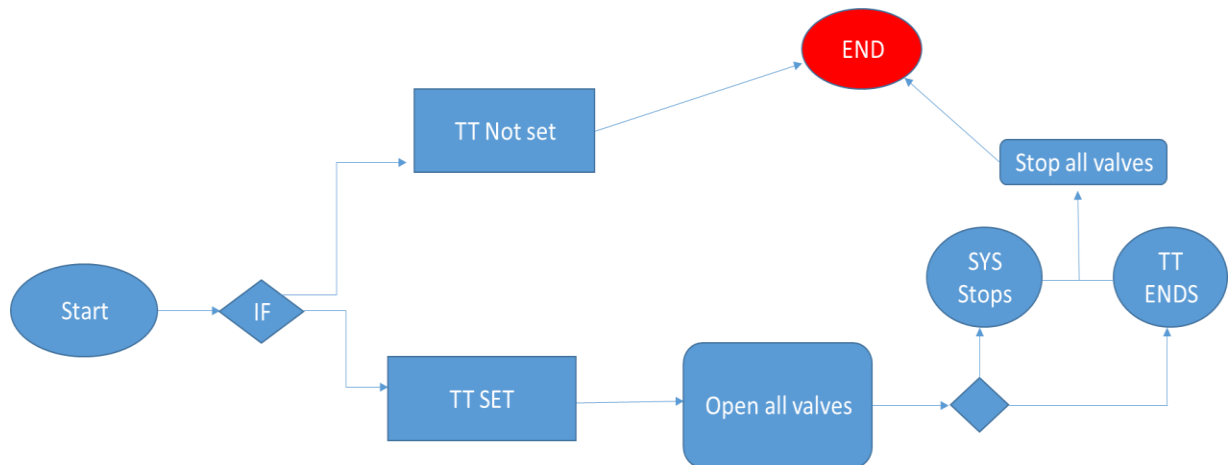


Fig 3.11 system auto shema

Before start system auto, must all values TT & amount of water sets, [Fig3.12] shows the system before start, and [Fig 3.13] shows the system after start.

After set all values, the system works and the Water engine and all valves can run.

- If the TT don't set the sys auto don't work.

- If one of the houses don't set amount of water, the valve not open.

Can stop the water to House (n) by clicking "off".

- If the water valve is turned off, it can not be opened, unless the manual system is working.

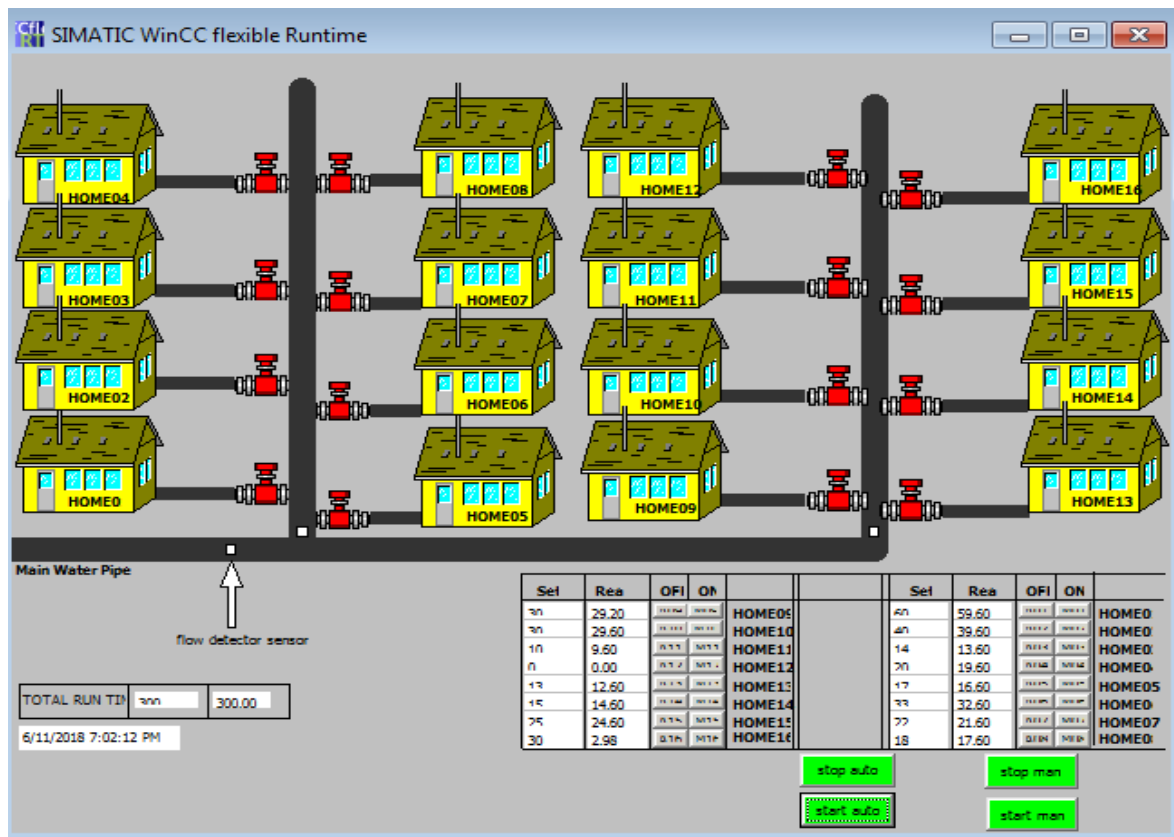


Fig 3.12 : system before start

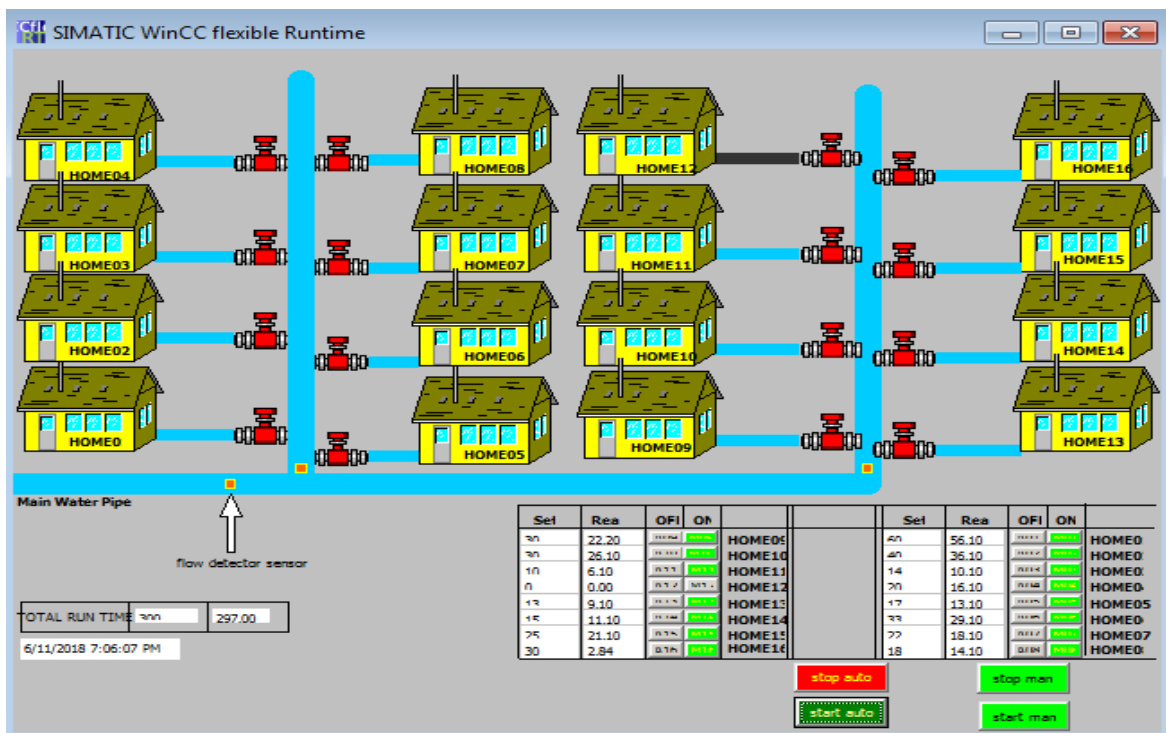


Fig 3.13 shows the start of the sys auto.

3.2- sys manual :

To make the manual system work must click on "start man" [Fig 3.15].

The system manual allow to controlle the vales of each house manually open and shut down the valve .

- If the manual system stoped , all valves stop working .

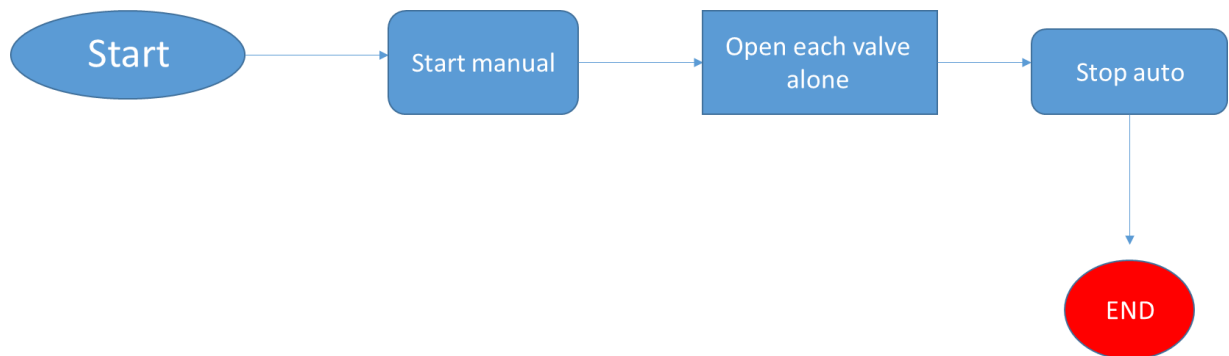


Fig 3.14 system manual shema

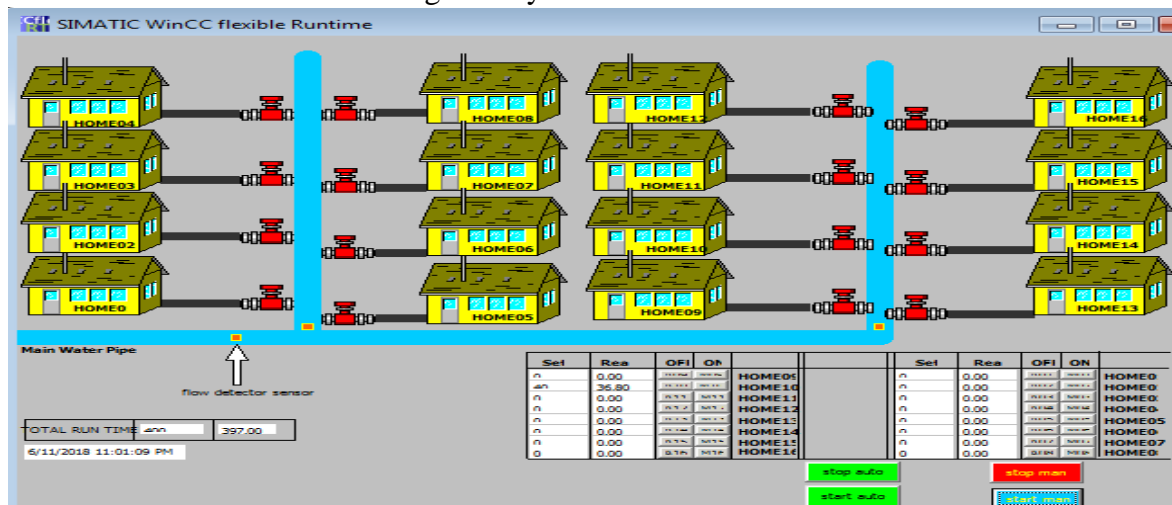


Fig 3.15 sys manual open WINCC

After all the houses get the amount of water, and TT not end . the valves open by other system we call it system force (post automatic) . Until the time is over.

- The sys work with auto system.
- If on of the valves is shout down manually from the start ,the sys don't open it .
- If on of the houses don't set the amount of water, the sys open it after work.

The schema in [Fig 3.16] show how the system work.

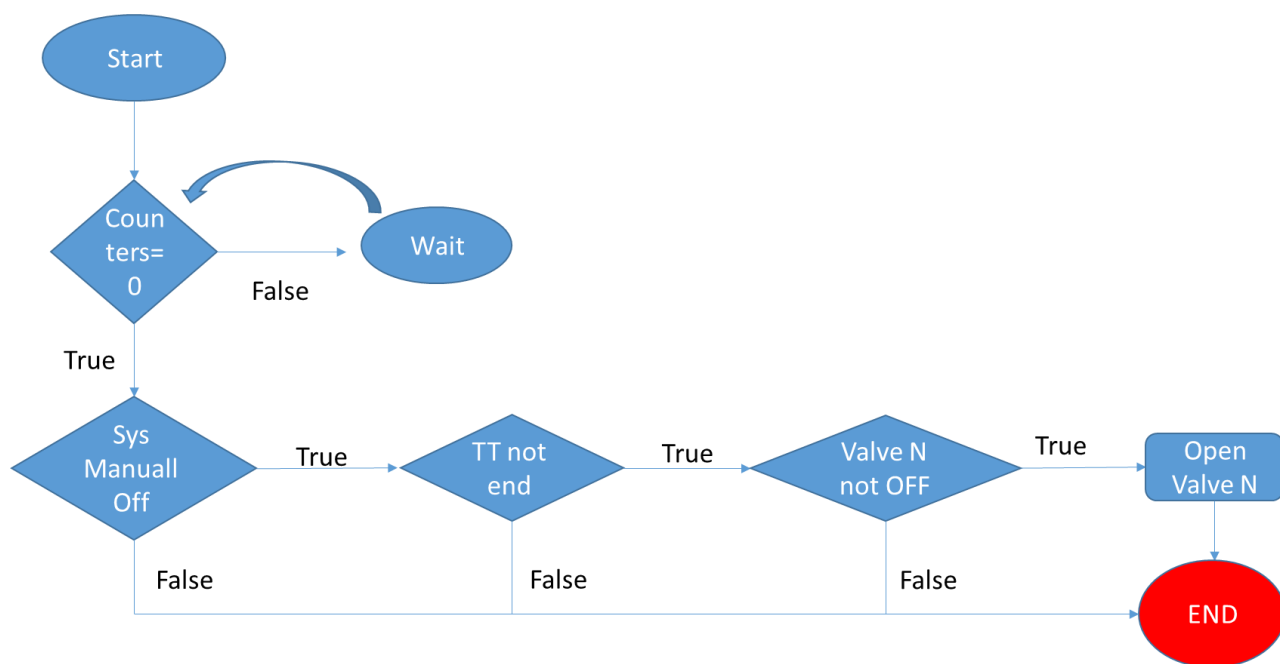


Fig 3.16 sys force (post automatic)schema

After starting the auto system the system force (post automatic) start with it.

Schema explaining:

- If all values of the amount of to each houses not sets "0", the system start automatically .
- If all values of the amount of to each houses sets the system wait till all valves closed the amount of water to each house reach "0" to start .
- If one off valves closed manually the system don't open it .
- If one of valves opened manually the system cant start .
- If the TT end before all valve shut down the system stops .

to create this system I made some change to simulate it. I changed the water counter with timer ,because the water counter work in the real time data , and must have all tools that I talked about it before (PLC , smart water meter, sensors...etc) the general concept is the same

4-Example of valve in the sys:

4.1 valve system auto

the system in valves is semi auto because its can close the valve manually even the system manual didn't work .

After the system auto run the valve open automatically see [Fig 3.17] [Fig 3.18].

- If the value set the house amount of water .
- If not the valve stay closed tell the post automatic start, or open it manually.

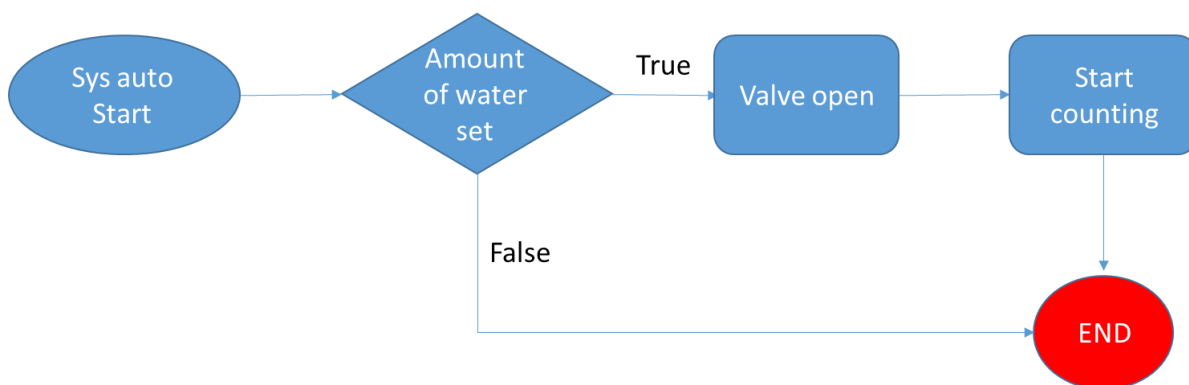


Fig 3.17: valve N sys auto schema

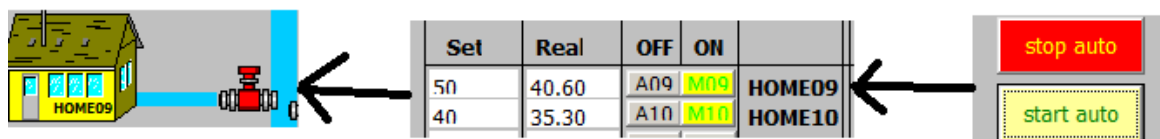


Fig 3.18 valve (n) auto opening

4.2 valve system manual

the control manual of valves work if the manual start .

After run's the system manual can open the valve

The valve stops if click on "off" or system manual closed .

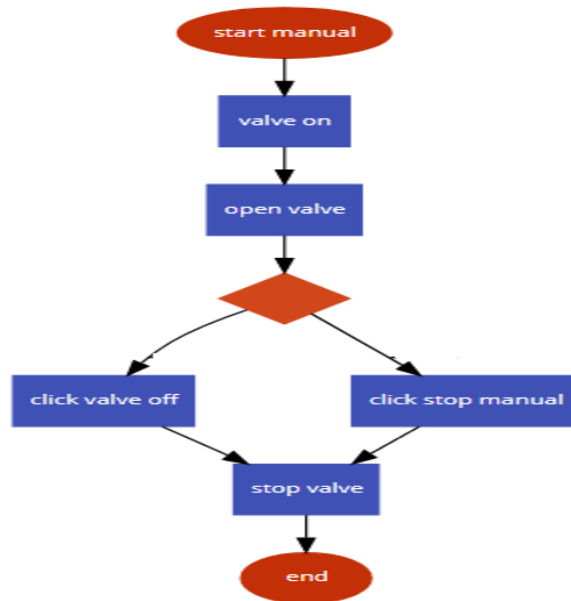


Fig 3.19: sys manual valve N schema

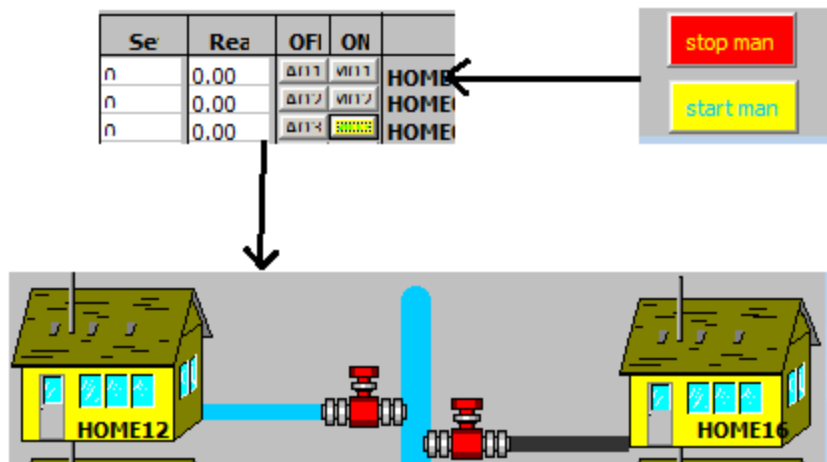


Fig 3.20 valve (n) manual opening

4.3 valve system force (post automatic)

This system works after all valves shut down .

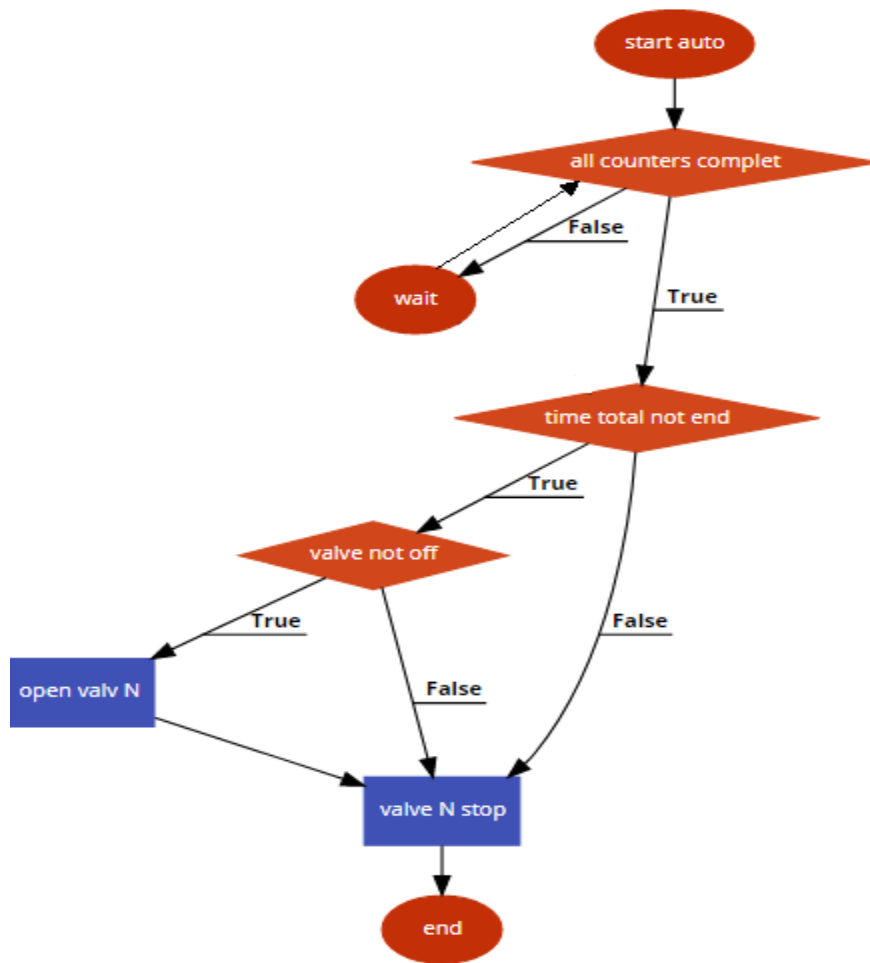


Fig 3.21: sys force schema valve N.

Schema explaining :

- If all valves shut down "the amount of water reach 0" the system start
- If the (TT) ends before "the amount of water reach 0" the system don't work.
- If the valve shout down manually the system don't open it .

Result :

The SWM is applicable system to non smart cities if all Tools and compound present, its save time to take action to repair the leaks and give better control of water flow.

the simulation shows that the water flow can manage easier if there is (SWM) and its reduces the wasting of water.

GENERAL CONCLUSION

In this thesis, we presented a smart water management system similar to those of smart cities. In a simulation, we applied SWM in a non-smart city.

In the first chapter of this thesis, we saw the definition of smart cities and its different component, and its evolution, and come off conclusion that the future direction of countries is the smart cities, especially after the increase in the world population, because smart cities give a better control of things, and make living a lot easier through their automatization and efficiency.

In the second chapter, we highlight the importance of SWM in smart urban areas. We presented the different tools and technologies used in SWM, then we take look to smart water grid and its component (platforms and networks) and global trends toward SWG technologies from some cities and companies. We have concluded that SWM ensure a better quality for the water distribution and consumption management, and that it's a solution to the various problems mentioned.

The third chapter contains our application of the SWM system in the form of a simulation, using two software (WINCC flexible and step7). In the end of this study, we have seen that SWM is applicable to the city of Bousaada if all compounds are present. Due to its importance, this system is a necessity for the city.

In conclusion, smart water management can play a key role in the transformation of cities and developing countries into smart and sustainable cities, if adequate policies, stern governance, and broad stakeholder involvement are integrated into its planning and implementation.

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ملخص:

يوضح هذا العمل أهمية إدارة المياه في المدن الذكية، حيث ناقشنا تعريف المدن الذكية وخصائصها وكذلك تجربة بعض المدن في مجال الإدارة الذكية للمياه . وقمنا باقتراح و محاكاة لنظام إدارة المياه الذكية لحل مشاكل توزيع المياه في مدينة بوسعادة.
الكلمات المفتاحية: المدن الذكية ، إدارة المياه الذكية .

Summary:

This work illustrates the importance of water management in smart cities, where we presented the definition of smart cities and their characteristics, as well as the experience of some cities in the field of smart water management, we give a proposed and simulated a water management system for a district of the city of Bousaada.

KEY WORDS : Smart cites, smart water management.

Résumé :

Ce travail illustre l'importance de la gestion de l'eau dans les villes intelligentes, où nous avons présenté la définition des villes intelligentes et de leurs caractéristiques ainsi que de l'expérience de certaines villes dans le domaine de la gestion intelligente de l'eau. Nous avons proposé et simulé un système de gestion de l'eau pour un quartier de la ville de Bousaada.

MOTS CLÉS : Villes intelligentes, gestion intelligente de l'eau.