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CityPro; An Integrated City-Protection Collaborative Platform

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Abstract

It's a big challenge to deal with security in a city. Technology advancements are influencing our life, cities are evolving, and modern cities are referring more and more to digital technologies. Currently, a huge amount of standalone independent-systems operate in the city, their goal is to satisfy some business activities, e.g. banking, customs, hospitals, etc. Data collected by these systems represents, if integrated, a key element in any decision making process. This paper presents a, working, smart collaborative platform to integrate multiple systems to serve the surveillance activities in a city or country. It consists of a collaborative surveillance system, called CityPro. The architecture that we propose is a future vision to protect people and monitor public infrastructures, such as bridges, roads, buildings, etc.; it is designed to deal with and/or prevent abnormal activities like terrorist attacks. CityPro is expected to operate in live-mode by using (intended to use) city adapted IT-infrastructures. At the end of this paper, a typical case study is given, and challenges and future works are also discussed.

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Keywords: Smart cities; Digital cities; Software architecture; Event-driven collaboration; GIS; Business-intelligence; Data-integration; Big-Data;

1. Introduction

Public safety is a major feature for smart cities, and modern cities are exposed to emergencies like traffic flow, accidents, terrorist attacks, and crimes. The concept of "smart city" can be seen, from the perspective of technologies, as a complex arrangement (cohesive whole) of heterogeneous infrastructures and services that densely

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interact. The ability to capture events, integrate into an enterprise computing platform, apply fast processing, and share live real-world data is a key challenge that distinguish new worlds of intelligence and smartness. In Harrison et al.'s study [1], a smart city denotes an instrumented, interconnected, and intelligent city.

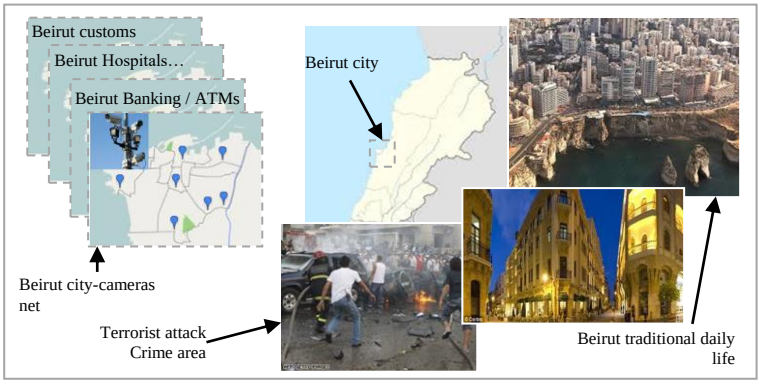

Fig. 1. Typical city activities, case of Beirut-city, Lebanon

It's a challenging task to ensure the protection of a city; however the emergence and invasion of information technologies may ease this task. Information produced by these systems is considered a fundamental component of security including geographic information. Geographic Information Systems (GIS) can be used for assessment and development of an emergency response. It helps in planning different scenarios and types of events, and facilitates creating the action plans needed to deploy materials or resources.

The main issue we are going to deal with in this paper is to provide a competitive and powerful city surveillance solution by getting extreme benefit from existing operational systems with least deployment efforts.

In this paper, Section 2 covers the previous and related works talking about smart cities and surveillance systems. We present deeply CityPro in Section 3, an integrated collaborative city surveillance platform. The proposed approach is still in progress (under work) and is intended to operate in an automated-supervised mode. The system is designed to deal with abnormal activities ranging from simple car accidents up to complex actions like terrorist attacks. It combines and inter-operates, for this purpose, heterogeneous standalone pre-existing operational systems; e.g. banks, hospitals, cellular and landline phone management engines, customs, police-stations, video surveillance networks, etc. (figure 1). Therefore CityPro is scalable and makes use of high performance communication infrastructure (event-driven based collaboration, broadcasting, etc.). It solicits techniques for collecting data for intelligent analysis and live monitoring. CityPro is supposed to generate and support decision and emergency executive-plans. A typical case study with scenarios and examples is given in section 4. Finally section 5 concludes, discusses, and states some future works.

2. Related works

In recent years, new trends in terms of security and safety arise with the arrival of smart spaces towards Cyber Security. Currently, there is a wide range of video surveillance systems that are used in different fields such as intrusion detection or traffic surveillance [2, 3, and 4]. However, City-Protection is a hot topic with quite a lot of literature behind it. Smart City, Surveillance systems, GIS platforms and big-data issues are omnipresent in this area.

2.1. Smart city survey

Smart City – Duravkin [5] proposes an approach to build a smart city based on the technology of SOA, which allows reducing the costs of developing new components and connecting existing ones with each other. Chourabi et al [6] identify eight core components of smart city initiatives and suggest an integrated conceptual framework to guide future "smart city" studies.

Surveillance System - Hancke et al [7] declare that by monitoring people actions, it is possible to determine a violent action, and more identify and recognize involved people. Wang et al [8] suggest using infrared video to track and detect pedestrians at night. Damn et al in [9] propose a framework using video sequences to detect people carrying objects (objects are not allowed in restricted areas). A crowd behavior classification algorithm is proposed by Wang et al in [10] for safety reasons. IBM Smart Surveillance System uses video analytics modules for urban surveillance, including moving object detection, tracking, and object classification. This idea was presented by Feris et al. in [11]. A semantic video surveillance system is given by Calavia et al. in [12].

GIS and Surveillance - GIS tools have been widely used for insuring public safety. The first to shed the light on the importance of GIS based solutions for security problems was [13]. ESRI started the project of "Home Land Security", it used GIS tools in all the stages of emergency planning from risk assessment. [14] discusses the fundamentals of GIS functioning within mobile devices, applications, and wireless networks in the context of homeland security and public safety. [15] presents Fusion Core, a public safety and homeland security solution architecture. [16] uses geospatial technologies to make a plan to fight terrorism in Afghanistan. [17] describes the terrorists attack risk status along the parliament road determined using a GIS overlay model. Xiong et al. [18] propose an Event-based Emergency Video Surveillance System with a GIS platform to allow the access to real-time video data of accident scene in a fast and efficient way. Sanjay [19] shows the utilization of GIS to identify the optimal number and location of observers (e.g. cameras) in order to ensure complete visual coverage of a geographical zone.

Big Data Issue - One of the solutions proposed to analyze big data is distributed computing as suggested by Jacobs in [20]. In addition, the Hadoop Distributed File System (HDFS) [21] is designed to store very large data sets reliably, and to stream those data sets at high bandwidth to user applications. Cisco IT built a storage cloud service called S-Cloud [22] to store, manage, and protect globally distributed unstructured data.

Cloud-based stores [26] like MongoDB [27] support the storage of huge volume of data, and allow elastic scaling for handling unexpected load. The concept of delegating jobs may ensure a good load balancing and minimize the traffic to main central-database. However, solutions like Lorena et al. [12], which analyze video data and detect abnormal aspects and give alerts, could also be used and integrated.

2.2. Position of CityPro

Alkandari *et al.* [23] perform a smart city survey gathering a large number of recent researches about smart cities platforms and case studies. But none of the case studies discussed the case of city surveillance where suspected objects (persons or cars) can be detected automatically to disclose danger before it happens. The surveillance must be done by the integration and cooperation of all city components with no need to add new entities that serve this goal. However, we observe, based on the above survey, that the latest research-works in the field of city surveillance are mostly focusing on protecting cities and public areas using the technique of video surveillance systems and cameras.

In contrast to above approaches, CityPro is a collaborative platform; it investigates new issues by combining information providers and consumers in a meaningful architecture. The CityPro architecture is repository based and scalable, the application operates in a collaborative-supervised mode and deals with live alerting and event-driven collaboration protocol. It uses advanced communication infrastructures and emerges Business Intelligence-Analytics and GIS tracking and monitoring technologies.

The goal of CityPro solution is to: *solicit technological-infrastructures of a modern city and get extreme benefit from existing operational standalone city-systems with least deployment efforts.*

3. CityPro; An Intelligent City Protection Platform

As we're heading toward a new world of intelligence and smartness, a lot of challenges can and will frequently occur looking at today's constrained resources. So the big concern of the research and industrial communities now is how to address these challenges to ensure a better quality of life. The goal of CityPro is, mainly, to protect a city, namely to insure public safety in a city by preventing classified incidents and reducing impacts in case an incident occurs. This requires the capability to collect rapidly relevant data from various reputable providers and process it

into actionable intelligence. It also requires the development of emergency plans to deal with critical situations (i.e. protect infrastructure), having current and accurate situational awareness, the perception of the things in the environment within time and space, and the projection of their status in the near future" [24].

3.1. CityPro CityPro design issues and challenges

CityPro can be seen as an integrated complex collaborative-platform. It is expected to apply unconventional technologies and treat with heterogeneous architectures by making together multiple systems (providers, partners, and a set of interdependent engines). It deals, due to the heterogeneity and magnitude of inter-changed information, with many technical and social challenges. Below are the most relevant challenges that CityPro platform may face.

Centralized and real-time control, Dependability and Availability: CityPro could operate in real-time mode; it is intended to frequently initiate worldwide collaborative session (most of components may participate) so the availability constraint is crucial. However, city-partner-systems are expected to operate in total standalone independency, each of which has its own working methods. Consequently, increasing complexity and session-interdependency increases the likelihood of unpredictable failure modes or cascading failures.

Data ownership, securing and privacy: Who will own the rights to access the data collected from the observing applications? What policies to specify and to respect in exchanging process? What data to transmit? How to secure transmitted data? How to assert privacy of people having their private information used widely across multiple systems? Those issues will be considered in the system infrastructure where the right tools to secure the system must be deployed.

Big data issues: The city surveillance system like CityPro is intended to collect and store data from various sources and interconnected devices to get an accurate view of an event. So a large amount of data will be generated; it can be expensive to store and time-consuming to process. It needs to be analyzed in a timely manner and expected to provide new insights to secure the city assets and citizens. Consequently, big data infrastructure and big data analytics are needed as new ways to design, develop, and operate complex infrastructures. Facing this problem, CityPro opts indeed for data-summarizing (towards data multi-levels) solution.

Integration issues: such challenges arise because each city-system relies on various applications and technologies. The vast majority of city systems are in an environment where existing IT assets are deployed. Efficient integration efforts are extremly needed, and Ontology concept is solicited as well.

Accurate decision making – Quality assurance: Taking the wrong decision and hence applying the wrong scenario may result in chaos that distracts the system and the society, for example giving false emergency alerts. This issue will and should be considered carefully when designing the functional process of CityPro.

To conclude, the CityPro platform approach is expected to undertake the above issues; however, the proposed solution is still under work, the challenge now is to propose an open and scalable architecture able to meet both technical and social requirements for a modem city surveillance purposes.

3.2. Collaboration-based software architecture

The purpose of this architecture is to build a smart city protection system by emerging the existing domain-specific components. The goal is to define a way of integration to support collaboration of these city-components with a "dedicated decision support operational center". These goals can be satisfied by applying the repository architecture style and getting benefits from existing communication patterns and protocols.

In our approach, we introduce a full-collaborative architecture which is a combination of three conventional architectures: Repository-based, Distributed, and Event-driven architectures. The target system is composed mainly of (figure 2): - Central system; the core system, -Collaborator-systems; information providers, -Consumers "Partner-Systems", and Connectors.

Central system: The cornerstone of the system; it consists of big-data ontology-based repository and a set of specialized components/engines. It deals with complex events based on predefined patterns.

Collaborator-systems (Information providers): A set of domain-specific independent (standalone) systems that coexist and span the considered territory/area. They mainly include governmental systems such as police-departments, customs, fire-stations etc., and non-governmental systems such as hospitals, banks, shop-centers, etc.

These systems operate separately and continually record detailed-data; each of which has its own operational techniques in its specific business domain.

Consumer systems (also called Partners): Decision support systems that are totally independent from each others and benefit from the "knowledge-base" supported by the central system. In return, these systems play also the role of "knowledge providers".

Connectors: Dedicated links materializing the collaborative inter-relationships between the CityPro components. They consist of dedicated data exchange protocols based on "Adapter Pattern / ETL like".

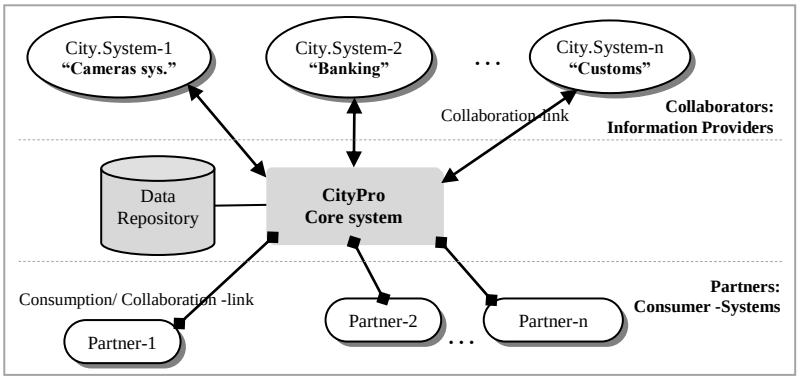

Fig. 2. City Protector overall platform architecture

3.3. CityPro central system architecture

The system is intended to deals with complex events. It emerges data-mining analysis techniques, advanced on-line monitoring and tracking technologies, and GIS geo-localization and visualization capabilities. It also supports and performs highly protected and secured collaboration tasks. The core system consists of a big-data ontology-based warehouse/repository and a set of specialized components/engines (figure 3).

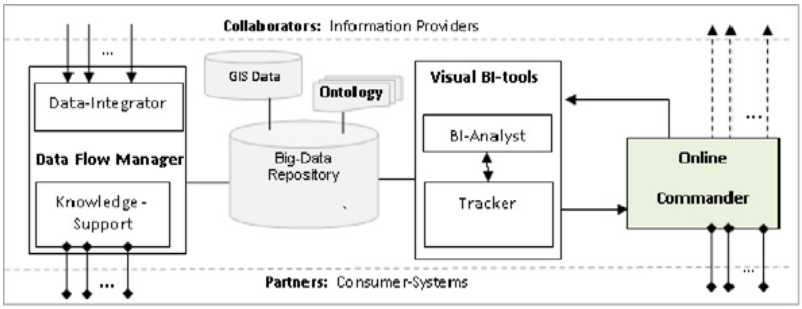

Fig. 3. City Protector core system architecture

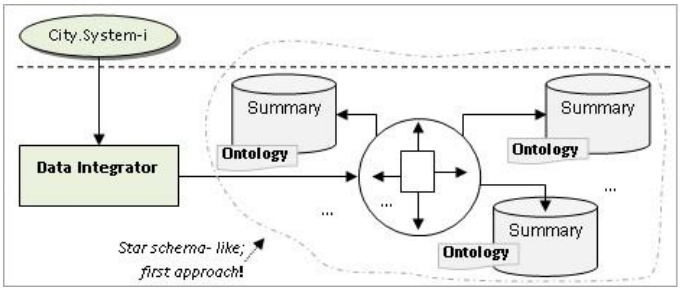

Fig. 4. Big-Data repository approach

Big-Data repository (Ontology based warehouse) – This component stores gathered information from collaborator systems. The used data model is star schema-like (first approached schema); it is an extended federated schema (we work on indeed, figure 4). Data coming from providers are summarized, integrated (adapter pattern/ETL like), etc., and should continually be enriched with the appropriate ontological data.

Business Intelligence (BI)-tools – This engine consists mainly of two software components closely-related: BI-Analyst and GIS-Like Tracker. It combines BI techniques and GIS capabilities. Here the GIS functionalities are Omni-present; we use indeed spatial intelligence to perform high quality multidisciplinary analysis and monitoring. The Engine maps incident/event location and integrates drive time for simulating emergency to predict what the potential risks are, what their consequences are, and how to prevent their occurrence (using emergency plans; minimizing their impact, etc…).

Data Flow Manager – Data exchange is made through the following automated methods:

Periodically: data comes continually from providers. The Repository should generate and emerge an up-to-date (versus applied periods) summarized information.

On the fly (event dependent): The central system asks providers for an instant detailed-data to perform an emergent task. Also Partners (consumer) may ask for instant data from the central system.

In both cases, strong and secure data exchange policies should be applied, they set-up what data are allowed to be exposed to and what security protocols used in data transfer process.

Online Commander (OLC) – It is an added tool, this component/engine acts as "City's Operating Room" (Figure 3), it plays a chief role in terms of surveillance intelligence. It applies an event-driven communication style and interacts with both collaborators/providers and partners external systems. The OLC presents the corner stone of the CityPro operational collaborative business process.

3.4. Event-driven collaborative and operational process

The system, from the BI-Engine, uses intelligent techniques to get benefit from knowing possible scenarios. The system mainly deals with current up-to-date data, it also uses mapping of historical information that includes where previous emergencies happened and how it could be prevented. The OLC, in its turn, puts in action the investigations done by the BI-Engine. Practically, two scenarios are considered probable:

- OLC vs. Collaborator/Provider: if deep inspections regarding the considered subject (incident, event, etc.) are needed, the OLC asks (emergency-plan) the providers to apply local-topical investigations and/or to deliver detailed subject-related data.
- OLC vs. Partner-system: here the communications between the OLC and partner-systems are bidirectional.
    - The OLC maps the investigations; it asks partners to proceed immediately in harmony with the agreements already in use. And consists indeed of local sessions initiated (at CityPro home-department) in order to co-monitor and co-supervise the tracked event. As a result, the OLC covers and controls the hall territory.
    - A partner may detect in its specific domain some troubles (e.g., suspecting an individual, car …); it thus triggers immediately the OLC core system, and delivers the appropriate data. Therefore, a partner-session is created at the CityPro home-department. Accordingly, the OLC activates and launches an emergency plan by broadcasting (notification message) the appropriate data to all partners. Involved partners become active-participants in a huge live tracking/monitoring session.

However, the role of OLC engine is critical, it applies the *UsualSpace* techniques [25] to dynamically propagate and convey information. The engine is expected to use advanced and high level multimedia and communication technologies; it will work in real time operational mode, and may operate remotely.

4. Formal Case Study

As we're heading toward a new world of intelligence and smartness, a lot of challenges can and will frequently occur to ensure a better quality of life. An interesting point to address is that the public safety and security is becoming increasingly challenging. Critical infrastructure needs to be protected as well. However, economic features

need to be taken into consideration when building a smart space. City protection policies are expected to deal with all of the challenges, and so this drives the need to create an efficient protection system.

Consider the case where our proposed system is hosted by the Ministry of Interior, responsible of protecting the city, which is authorized to access information in both public and private sectors. The City protection solution is designed to detect almost any kind of abnormal activities ranging from simple car accidents and up to complex actions/events like terrorist attacks. The system acts as the "City's Operating Room" and interacts/collaborates with the following stand-alone operational systems:

- Banking systems, which contains ATM machines and video/camera indoor surveillance system.
- Cellular (mobile phone) Network Operators. Land-Line phone Network Operators.
- Private surveillance system of shopping Malls; indoor tracking and monitoring.
- Wide-Public video/camera surveillance system deployed by the "ministry of interior" that keeps an eye on public spaces like roads, sites, and governmental buildings, etc.
- Social Networks (Facebook, Tweeter, etc.) Tracking Engines (SNTE).
- Customs (Agencies that control national borders); airports agents, coast crossing agents.
- Hospitals / medical records. Police stations. Etc.

Naturally, the subscribed providers/collaborators (such as specific Banking Systems, Cellular Network Operators, Land-Line Network Operators, Social Networks Tracking Engine, Customs, etc.) continually send data-summaries describing local traditional operations. The adhered partners/consumers (such as Police-Stations, Cellular Network Operators, Land-Line Network Operators, Customs, etc.), in their turn, operate as usual; they apply On-demand protocol for getting benefits from CityPro data-warehouse huge repository. Many scenarios may occur:

a) The CityPro core system may detect (via the BI-Engine) some troubles inside the collected up-to-date data; it then generates suspect-profile (relevant collection of information). The CityPro (via the OLC engine) sends the given profile to both providers and consumers and exhorts all components to add the suspect to a high qualified "Red-List".
b) Providers and partners may identify local suspects; they notify the CityPro with the appropriate information. CityPro investigates immediately the subject and accordingly it may invoke the above scenario "A".
c) Providers and partners refer to the local Red-List by activating a Live-Tracking process, they accordingly urges a mirrored-session within CityPro.

Practically, detecting a cell-call from a suspect (in Red-List) is followed by a notification to the central system accompanied with geo-location. In its turn, the central system determines the geographical sector where the suspect is. Here, the GIS platform is used to locate the geographical coordinates of the call. The position is plotted on the map in order to locate the nearest police-station to be notified and keep monitoring the suspect in case he is moving. However, the central system sends a request to the involved systems located in the given sector in order to get historical (cameras, transactions, etc.) and real-time data of the scene, etc. The "Police-Station", as consumer system, applies suitable on site procedures in order to arrest this suspect. The "Police-Station" then forwards related information to the central system. All the data are recorded in the repository for future analysis.

5. Conclusion and Future Works

In this paper, we presented CityPro city surveillance system architecture, it is still under work, and the proposed solution is the cornerstone of a huge project, it should support the collaboration of city components (existing operational systems) with centralized supervised-control. The core system supports big-data ontology-based warehouse as an evolutive-repository. The system is intended to apply BI-analytics and to deal with complex-event processing; it is characterized by its scalability and inter-operability. We also suggested building our system using GIS facilities which allows location-based tracking and monitoring.

At the end, a formal case study is given to illustrate and show the flow of actions upon detection of an interesting event. However, we faced during this work challenges that deal with: collaboration/communication protocols and data exchange policies, heterogeneity and availability of all parties, privacy assurance, system scalability, and big data issues, etc. The big challenge is to provide desirable solutions. In one word, we tried, in this paper, to describe horizontally the proposed approach by concentrating on the architectural design phase, talking about components

and formal protocols, issues, challenges, formal scenarios, etc. Now, the near future will be time to go vertically, to examine and study, to proof and validate each component, and each method or concept of the proposed platform.

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