International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 7 July 2023, pp: 199-204 www.ijaem.net ISSN: 2395-5252

Sensor-to-Sensor Networking Concepts Based on Local Mobile Agent Platform

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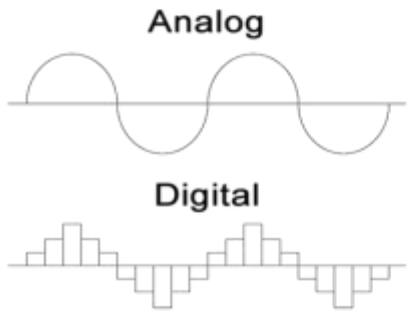
Date of Submission: 01-07-2023 Date of Acceptance: 10-07-2023

ABSTRACT

A sensor is a device that measures physical input from its environment and converts it into data that can be interpreted by a machine. Sensor based programming is very useful in networking. In Wireless sensor networks, individual sensors commonly have different profiles and contexts and therefore different needs. In this paper, itaims at extending networking platform by allowing sensors to support each other with services that mutually fit their differences.It propose a local agent -based platform where sensor nodes delegate software agents (mobileorstatic) to collect valuable data about the neighboring sensors and the spatial characteristics of their surrounding environments.They have also to maintain one-to-one relationships with their neighbors, by understanding their mutual needs. Sensors have thus to offer services to their next hops to achieve sensor-to-sensor latform. For instance, a sensor node would only send to its neighbor data in the format that can process while making sure that is trustworthy and has enough resources. This requires from sensor to have an updated knowledge about status, capabilities, and context.

I. INTRODUCTION

There are two types of electronic sensors: analog and digital. Analog sensors convert physical data into an analog signal. Analog sensors are much more precise than digital sensors, which are limited to a finite set of possible values. Because analog signals are continuous, they can account for the slightest change in the physical variable (such as temperature or pressure). Digital signals, while following the general trend of variation, are restricted to fixed data (ones and zeros).



Technological advances have been very beneficial in getting closer to users, acquiring their explicit and implicit data, as well as acquiring relevant data on their surroundings. In this context, Wireless sensor networks can improve and expand the quality of services across a wide variety of settings. This is particularly possible thanks to the context awareness ability of sensors and their ability to adapt and support new events of interest. Several research works have benefited from those capabilities to deliver services to the end-user. In this paper, itargues that further benefits could be obtained, not only by delivering services to the end-user, but also by adding personalization within the sensor network itself. This means that sensors should not only sense/process/forward/move according to their own capabilities and/or the end-user preferences. This implies exchanging an important volume of messages that may not be supported by the available bandwidth and the current level of energy and processing capabilities of the sensors. It may also require collecting contextual data (e.g. characteristics of the space where these neighbors are operating) which are not necessary available at any of these neighbors. To this end, itbelieves that it is important to endow sensors with autonomy and intelligence allowing them to provide peers with the right data at the

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right time. Local agent technology appears then as a serious candidate for this task alocal agent is a computer system which acts autonomously in its environment to meet its design objectives. Thanks to their autonomy, agents can operate in an environment which is open, highly dynamic, uncertain, or complex. Similarly, sensors are required to behave autonomously within a distributed network and adapt their behaviors to the changing environment without human intervention. In addition, sensors have to collect data about their neighbors (to provide them with services) without compromising the overall performance of the network. In this context, the localagent community has an adequate set of formalisms, algorithms, and methodologies which can address these challenges.

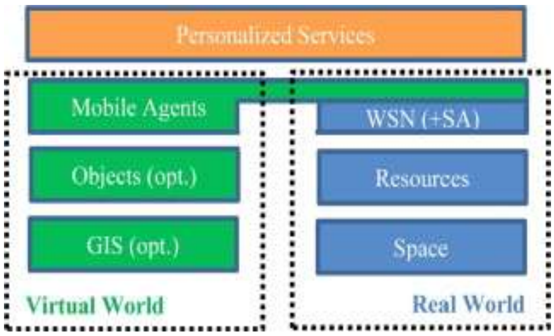
II. LOCAL AGENT-BASED PLATFORM

General view of our local agent-based platform In order to offer service to its neighbor, a sensor node has to take into account the environment context, the requirements and constraints of its neighbors, as well as its own goals and restrictions. To this end, and under such circumstances, the Real World environment is not necessary the best place for the following reasons.

The process may involve the collaboration of several sensors with a high volume of exchanged messages. Communication is the main energy consumer function of a sensor. Offering service to the other nodes may require from a given sensor more processing.

This is often very difficult if not unfeasible due to its limited memory and CPU. The decision/action of each sensor may depend on the spatial characteristics of the surrounding space (elevation, slope, etc.) and the location of the other resources/sensors.

These data are, at best, partially available for a single node in the real world. Individual sensors have only a partial vision of the overall environment (status of the global network, context, etc.). As each sensor is only aware of its neighborhood, the undertaken actions are not necessary positive for the overall network.



Virtual World

The Virtual World is a platform where software local agents can: (i) meet each other to share data and (ii) optionally, access to the GIS data to apprehend the geographic characteristics of the space surrounding the current location of their original sensors as well as the resources to be managed/monitored. Concretely, if Mobile agents aim at meeting to exchange data between them, the Virtual World could be simply a super node with extended memory and CPU capacities. However, if Mobile agents need to access to the GIS data, the Virtual World would rather be a remote host where a dedicated software platform provides Mobile agents with spatial data. The mobile agent, once its work is done within the remote node or platform, has to communicate with its original node in order to feed it with the data required to offer a service to neighbors. The mobile agent has then to choose between migrating to node and sending a message to node. This choice depends on the network status and the volume of data to be sent.

III. SENSOR ENHANCED CAPABILITIES

The Semantic Sensor Network ontology targets at the formal and machine-processable representation of sensor capabilities, properties, observations and measurement processes. Observation is a key concept of SSN, it is defined as "a Situation in which a Sensing method has been used to estimate or calculate a value of a Property of a Feature of Interest". The class "ssn:Observation" provides the structure to represent a single observation; hence it is related to a single measurement and attributed to a single property and to a particular Sensor. The result of the sensing process is modelled by the class "ssn:SensorOutput".

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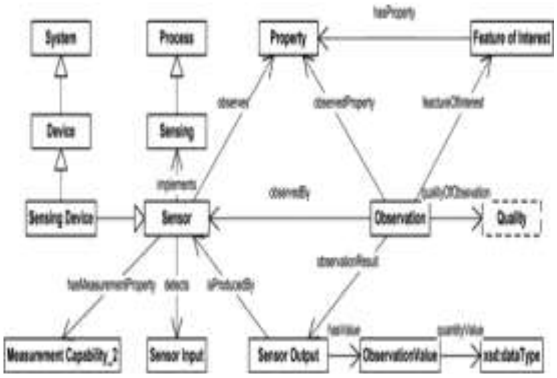
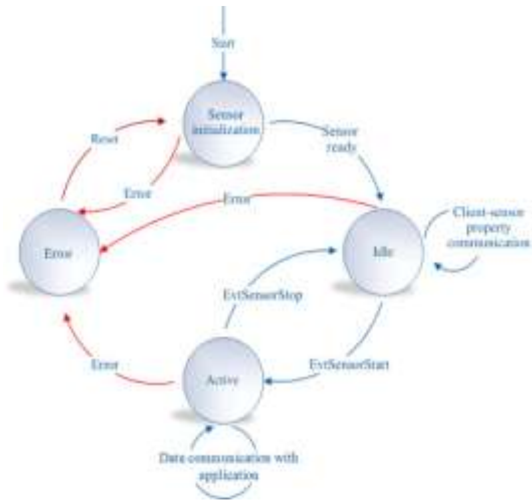


If data analysis is necessary, the sensor may carry out some processing, such as data filtering, data aggregating, and data formatting with respect to the expected level of details. Once the personalization of data processing is achieved, the sensor carries out the personalization of data communication by setting up the size of data packages while taking into account the requirements of the beneficiary peer. In the three cases (data acquisition, processing, or communication), if the output is not as expected, the receiver sensor may make some recommendations to the peer based upon its awareness about the current situation and its surroundings. Figure summarizes the different capabilities of our sensors. Each sensor has the three common capabilities which are Processing, Routing, and Communication in addition to Relocation for mobile sensors. Itproposes to add four other capabilities to achieve platform: Space-awareness: a sensor needs to know the characteristics of the space in which it is operating in order to provide a better service to its peers. For example, knowing that a geographic obstacle (e.g., mountain or hill) is between its receiver may push sensor to move to be reachable by its receiver. Space-awareness requires data which is provided by the Virtual World. Trust-awareness: a sensor may need to know if a neighbor node from/to which it gets/sends a message is trustworthy or not. This implies different processing (e.g., by encrypting data) or routing (e.g., by choosing another route) if the destination node is more or less trustworthy. Data about sensors trustworthiness may be collected at the sensor itself based on its own experience with the targeted node or at the Virtual World based on the feedback of the other nodes. Semantic-awareness: a sensor may perform a smarter forwarding if it can understand the semantic of the data. It will then avoid sending useless data to sensors. More details are in. Mobility: this capability is supported by the mobilelocal agent and aims at collecting the necessary data from the Virtual World to feed all the other capabilities.As shown in the Figure, Windows supports four possible sensor states: Initialization, Idle, Active, and Error.



Initialization: The sensor enters into this state as the startup and will transition to idle state only when it is ready to respond to native API calls.
Idle: The sensor enters this state when it is ready to respond to client application for requests and configuration of sensor capabilities/properties and data field ranges.
Active: The sensor enters into this state when the client application calls EvtSensorStart . This causes sensor to start with its default properties or with the properties set by sensor class extension. In this state the sensor will take active measurements of its sensor parameter(s) and send data to the requestinglocal agent as per the set configuration. The sensor will transition to Idle state when the application calls EvtSensorStop to stop the sensor.
Error: The sensor can enter into this state from all of the sensor states at the occurrence of any error. User intervention/reset may be needed to recover from this state.

Enhanced Capabilities

It is here worth mentioning that mobile agents, when used in WIRELESS SENSOR NETWORK, reduce the message traffic and thus save energy. Several research works have indeed confirmed this. In addition, in our platform, agents migrate only if this does not affect the bandwidth. Second, the Space-awareness capability implies being in a Virtual World where resources (computation and energy) are relatively abundant. Finally, making sensors aware of the trustworthiness of their neighbors and the semantic of the forwarded data requires from each sensor to

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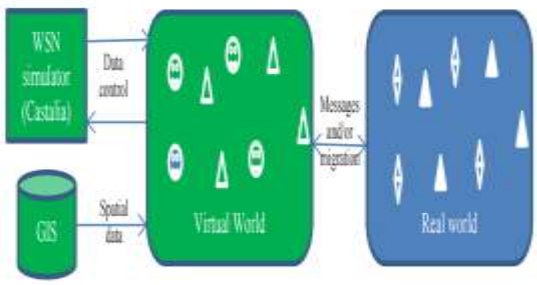
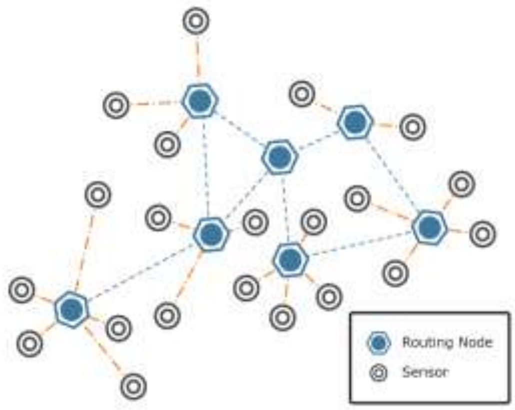
collect data (from its neighborhood) and performs extra processing. Nevertheless, when these tasks are performed by the mobilelocal agent in the Virtual World (e.g., a super node with extended memory and CPU capacities), the WIRELESS SENSOR NETWORKoverall performance is not really affected. The network may provide better services (by supporting trust and semantic) at a cost of installing more super nodes (if necessary), allowing agents to migrate through the network (when possible), and adding little complexity on super nodes (where resources are not as critical as in simple sensor nodes). The only case where simple sensor nodes may have to perform significant extra processing are when Mobile agents cannot migrate (e.g., due to limited bandwidth) to the Virtual World. In this situation, a sensor which is running out of resources may suspend its personalization activities and focus on its primary functions (data acquisition, processing, and routing). To conclude here, sensors endowed with enhanced capabilities offer better services to each other and thus to the end-users. However, this implies more or less extra usage of resources (energy and processing). Itthinks that each WIRELESS SENSOR NETWORK designer, depending on the constraints and objectives, has to find a compromise between quality of service (provided by the enhanced sensor capabilities) and resource usage.

IV. IMPLEMENTATION OF WORK

In this section itpresents two different proofs of concept to the platform presented. The two illustrations concern two main tasks of sensors, namely, routing and relocation. They show how the principles of our platform can be used to provide more routing and relocation.



Regarding the routing problem, most of existing routing protocols are based on one main criterion - power consumption- at the expense of other aspects such as reliability, security, or efficiency. To achieve a more sensor-to-sensor routing, many requirements have to be taken into account apart from power saving, namely, sensor mobility, location, space, semantics, quality of service, and trust/security. It is already proposed a generic multi-criteria routing platform where the selection of the best neighbor hop (to which data should be forwarded) is according to the environment (context), the end-user constraints and requirements (sensor-to-sensor personalization). As suggested by platform in, the sender node S chooses the next hop based on among other criteria- the data (level of energy, location, supported security level, semantic capabilities, etc.) collected about its neighbors. To support this platform, ituses the agent-based platform of the present paper. More specifically, each sensor node S may use a mobilelocalmobile agent (if the conditions are met neighbors or to the GIS-enhanced Virtual World according to the context. Mobile agents are thus responsible of exchanging data between each other on behalf of their original sensors. The Virtual World is implemented as a java application alimented by a GIS database to mimic the Real World space. The sensor-like behavior (e.g., routing algorithms) of agents within the Virtual World is ensured by the WIRELESS SENSOR NETWORK simulator engine Castalia. Currently, agents are created at the java platform (Virtual World) as thelocal agent migration between the Real and Virtual World is not yet coded. Our priority was in fact to prove the concept of the agent-based Virtual World as a tool to achieve sensor-to-sensor personalization.



It experiments show that routes found by agents are much more than those delivered by traditional routing algorithms. When a node n receives a packet it selects the most appropriate next hop to forward data based on the semantics, and the security level supported at each neighbor node as well as its location. This is the sensor-to-sensor personalization facet. Node n compiles thus a lot of data about its neighbors in order to choose the right sensor. Moreover, depending on the enddifferent weights of the selection criteria applied to each neighbor. This is the end-user personalization facet. Consequently, the combination of the two personalization facets determines the final routing path. This path is not necessary the shortest. For instance, if the level of security supported at each neighbor node is the main selection criterion, the route is longer but certainly more secure. More details/results about our personalization-based routing platform and can be found in. Concerning the relocation problem, it pointed out in that relocating sensors in a dynamic large-scale environment, such as a forest in fire, is not an easy task and thus has to be planned carefully. To deal with this problem, it proposed to plan the relocation in a Virtual World, which is synchronized with the real environment. In this Virtual World, itcombines both simulation-based planning and agent-based planning to conduct relocation. However, it did not implement thelocal agent migration process yet. Our aim was only to prove that within an enhanced Virtual World agents are capable of finding much better relocation plans than what sensors would have done.

V. CONCLUSION

It is proposed an agent-based platform for sensor network where sensor nodes delegate software agents (static or mobile) to collect valuable data about the neighboring sensors and the surrounding environment. It also gives accessibility to more refined data. All this data can then be used by sensor nodes to provide services to each other. While sensors are getting data from the Real World, agents are collecting data from the Virtual World. Putting both types of data together makes sensor nodes more intelligent and more autonomous. It showed how sensor-to-sensor personalization can be achieved for specific tasks such as routing and relocation. The present work actually gives the supporting platform for these applications. It are currently working on defining other aspects and applications for the sensor-to-sensor personalization. It are particularly interested in endowing sensors with a stronger trust and reputation model so that they can provide more secure services to their neighbors, with more semantic awareness to avoid forwarding useless data to the other sensors, and with more space awareness to provide services which can take the geographic characteristics into account. Regarding the localagent technology, itis working on building our own platform which will be able to provide agents with mobility, space awareness, and efficiency. Itis indeed confident about the importance of this technology to solve many WIRELESS SENSOR NETWORK issues. Indeed, even experimental sensor localagent technology has become sufficiently reliable for operational use in the field.

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