Mobile Middleware for Body Sensor Network:A Grid Approach

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***Abstract*—Existing mobile middlewares for BSN (Body Sensor Network) have software agents both on sensor and gateway nodes. Software agents on BSN nodes depend entirely on that of gateway to connect to server. There must be a way by which sensor nodes themselves can communicate in BSN and connect to server.This paper solves the problem with a grid approach for mobile middleware on BSN. Sensor nodes (equipped with this middleware) with grid computing can operate entire BSN and perform QoS and security operations.**

I. Introduction

Wireless sensor networks have the potential to greatly improve the study of diseases that affect motor ability. Small, wearable sensors that measure limb movements, posture, and physiological conditions can yield high-resolution, quantitative data that can be used to better understand the disease and develop more effective treatments.[1]

Body sensor network has number of challenging issues associated with it. [1]depics three challenges related to clinical requirements namely battery lifetime,operation tuning according to radio bandwidth and energy availability and confirmation of high-quality and clinically relevant data. Quality of services is another challenging issue.[2]discusses some of related issue namely prioritized data stream service, asymmetric QoS framework, radio agnostic QoS, adaptive bandwidth scheduling etc. Often heart activity reading is given more priority than body temperature reading. A glucose data stream might be assigned low priority on normal condition but might be given higher priority if there is nearest reading of hyper or hypo-glycemia .Body sensor network often involve node and aggreator -built star topology and thus encourages asymmetric QoS features. Existing body sensor network consists of different radio networks like IEEE 802.15.4 or Bluetooth or CC1000. Interoperability amon those is a challenging issue.Sensor nodes are effected by adverse fading of human body or interference from co-existing network or RF emiting devices. Adaptive QoS scheduling is required for statistical bandwidth guarantees.

Wearable personal monitoring devices now a days can record and archieve user activities for medical, safety reasons. A software architecture is needed to 'faciliate development of such wearable personal monitoring application, promoting their modularity and component reuse, to provide a simple modular architecture into which different classification algorithms, communication protocols and data filters can be integrated as components with well-defined interfaces'[3].Critical problems of distributed interprocess communication, signal processing and sensor data classification encourage the development of a generic software architecture. MIThrill 2003[4] created such an architecture to combine features and practices from a range of research systems and methodologies and they did it with an open, modular and flexible way.

Existing middlewares for BSN use gateway that collects information from sensor node and sends to server. Often this middleware is placed in a mobile device and people have to carry it with him. But it is not mobility in real sensse. We can think of a middleware consisting of only BSN nodes. The concept of grid computing comes at this point. We propose a grid approach based mobile middleware that will use distributed computing to overcome the limited resouce of BSN nodes. We have proposed QoS and security approach for it based on mobile grid environment.

II. Related Works

A lightweight middleware for wireless body area network has been developed to ' simply and accerlerate the development of wireless hardware applications by providing highly reusing codes'[5].Its main functions are 'data acquistion, dynamic plug and play capabilities, on the sensor reconfiguration, resource management (sensor sleep wake up, critical self wake)'[5] and 'security feature as a means to protect critical sensor data from malicious/ unauthorized parties'[5].This middleware receives raw data from sensor nodes,processes and transmits to application (data acqusition). To avoid data collision in context of multiple sensor devices, WBAN Mac scheme (based on star topology and a master slave) has been used.Urgent mode of WBAN MAC communication is used for response message of resource control commands.It includes Skipjack[6], a lightweight encryption algorithm to prevent unauthorized access to confidential data.It uses reconfiguration states like get sample rate, set sample rate or critical self wake to change properties of sensor nodes on the fly. It has resource management schemes like sensor once-off, sensor toggle, check battery level and notification to control and manage each of sensor nodes in a network.The middleware consists of two major components-upper and lower middleware. The upper middleware resides in J2ME[7] coded mobile device and the lower middleware resides in nesC coded sensor nodes. Gateway sensor node uses basestation, a proprietary program by TinyOS 2.x[8]. The gateway and sensor nodes communicate over 802.15.4 [9] and Imperial College BSN is used as the BSN platform.

Self-Managed Cell-A Middleware for Managing Body Sensor Networks[10] proposes 'a policy based architecture that uses the concept of a Self-Managed-Cell(SMC) to integrate services, managed resources and a policy interpreter by means of an event bus[10]'.SMC is an architectural pattern of heteregenous components(both software and hardware) and can change dynamically to user's activities, communication capacity etc. Policy based approach determines system's adaptibility to change in events, contexts or requirements.SMC's core functionality consists of discovery service, event bus and policy service.Discovery service detects sensor,device or other SMCs. Hardware and software components of SMS are distributed with events with event bus.Policies determine the behavior of SMC.[10] has given a prototype to monitor the heart rate of a patient of heart-disease.SMC consists of Gumtix running SMS core services, EKG sensor,accelerometer,temperature sensor,GPRS enabled mobile phone and GPS. In a generic architecture (over TinyOS) ,BSN nodes are discovered dynamically and nodes can publish events in event bus in SMC.BSN motes are equipped with sensors those can sense different physiological properties

III. Challenges for mobile middleware on body sensor network

Body sensor nodes have to run sophisticated programs and multiple applcations may correspondent to a single node.Yet, relatively less attention is paid to QOS issues like delivery latency, sensory, accuracy, energy consumption, data througput etc. Existing sensor middleware prefers best effor service, not considering application semantics. Programming tradeoff between QOS and resource-consumption is tedious and errorprone. However,some middlewares adopts QOS features in different ways. MiLan[11] takes specification about the minimum QOS requirement and adopts network to it. But, it minimizes resource consumption at its possible level.In a monitoring system,while most of the time nodes will find nothing interesting. Making all nodes engaged to that work is just power consumption, so a sparse subset of nodes are engaged in the work. When a phenomenon occurs, then QOS of related nodes are increased. Thus proactive approach enables MiLan to provide higer QOS remembering power consumption. Autosec adopts resouce allocation to provide QOS. It maintains a directory service which gives the current status of the network.Depending on current status,it gives resource allocation policy.Directory service maintenance, resource allocation policy is a challenging issue.

Realtime monitoring is also a part of QOS. Message and actions should be functional on time at right place.DSWare, publish subscribe middleware relies on standard realtime packet scheduling mechanisms like Earliest Deadline First.RAP uses real time query processing technique.It has velocity monitoring scheduling that uses spatial properties of network. A user issues a query with certain period, deadline and data refreshment reqruirements. As data is sent, its velocity determines how urgently it could be forwarded.A message with possibility of missing deadline has better priority than one that will be meeting deadlines.

Sensor nodes communicate confidential and sensitive data on patient's health.There must be measure to restrict unauthorized access to confidential data.The security is still in early age and too much work have to be done in this area[12].[12]also depicts some problems on sensor security.Sensor nodes are generally developed with small nodes and spread over potentiall hostile area. It thus makes it open to the attacker. Limited energy of sensor nodes are attractive for attackers who force to exhaust their energy and die.Due to limited resource, availability, low computational power, most existing algorithms and security modes are not suitable for sensor network[13]

IV. Grid mobility approach on middleware

To provide service of a guarranted quality while maintaining user's profile and addressing characteristics of mobile devices and limited availability of resources[14], grid middleware is an efficient solution.It is extremely important to develop system that provides effective QOS management and allows mobile users to benefit from the service requested, regardless of users and user's movements.Grid provide innovative access to distributed data.Members on a grid are provided with wide scale computational data and resources toward same purpose. Grid makes of use of idle resources available on internet to perform distributed computational operations[14]

Grid,with rational use of resources of a distributed network may impact on load balancing, QOS management, secure access.Grid impacts on the mobile middleware in different ways.It provides effective management of distributed data to move to close to user or to manage overload or fault tolerant situations. It manages services according to user device-as a result the same user gets access to services through different environments by the presence of different terminal equipments. It also provides service discovery using distributed strategies based on data replication.

In a wireless infrastructure,co-operative and resource sharing techniques become an essence.Grid computing in this case becomes major strategy for ad-hoc network.Wireless grid introduces grid computing concept to resource limited devices so that they can carry on parrallel operations by sharing idle devices.Its peer-to-peer paradigm discovers resources and services of devices..Its component based programming binds software modules of of shared nodes.In this way, mobile grid has become a challenging issue in mobile middleware for adhoc environments like body sensor network.

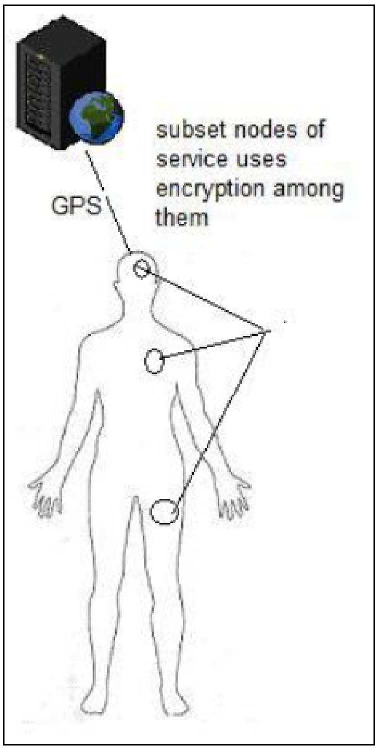

Fig. 1. Encryption among nodes of a subset of specific service

V. Proposed Grid Approach

A. Architecture

Security module of this mobile middleware consists of three main components.Authentication and authorization, permission, message integrity and confidentiality.Authentication features allow whether requesting node is valid or not. It also includes whether the service requested by the requesting node is valid or not.Permission detects the access permission on body nodes or service. There will be subset of nodes for perticular service (blood-pressure, temperature calculation etc). Nodes of same service will have access permission to the only nodes of that subset or that specific service[Fig-1]. It also includes permission variances like http,socket, file or runtime access-rights.Special instance of permission module will control over the longevity of cluster node.This will control how long the cluster node will hold the clustering property and who will become the next cluster for immediate service.Integrity and confidentiality feature enable that message is not altered or ready during transmission.Security module has the option to add protocol, encryption, signature depending on the service or the body organ. QOS module has two major components-proactive and reactive.Proactive module ensures high QOS ensuring low-power consumtion. A subset of all nodes related to a specific service will monitor the status.At occurence of any critical session,all other nodes will be triggered to ensure high QOS standard [Fig-2]. Reactive module with realtime query processing will use spatial property of the network. Here the body sensor node sends a query with certain period, deadline and freshness requirements. When a message is sent from a node, its velocity is used to determine the current QOS condition of the network.

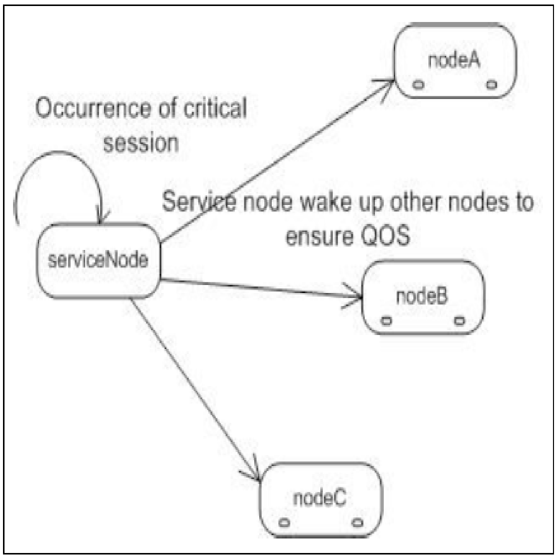

Fig. 2. Proactive QoS mechanism in proposed middleware

B. Prototype

This middleware is built on OSGI specification[15], a industry standard software development paradigm.There are three major modules-service, impl and slick. Service module contains definition of services namely core, security or QOS.Core service contains data or control management,protocol management etc. Security service contains three parts for authentication,protection and integrity. Proactive and reactive features are placed within QoS.Impl directory contains implementation of sections and their subsections of service module.For example,ReacMan implements reactive QoS mechanism described in the paper. slick is last module that creates testing environment in the middleware. Implementation of any protocol or service is tested by creating two instances within slick module of the middleware.

Let us go inside the design of this mobile middleware[Fig-3]. DataMan exchange packets within the sensor network.ContMan controls connection between nodes and connection to GPS.It also has the property of change node properties on the fly by getting or resetting sample rate, controlling critical awake state.ProtMan controls the variances of communciation protocols (802.15.4 or Bluetooth), AuthManager, PermManageer and IntegrManager are involved in ensuring security mechanisms authorization, protection and integrity. ReacMan deals the dynamic QoS management while ProacMan engages some nodes of a subset nodes of a specific service. These nodes trigger other idle nodes at any critical situation.

To add a new service servA(for example, new monitoring

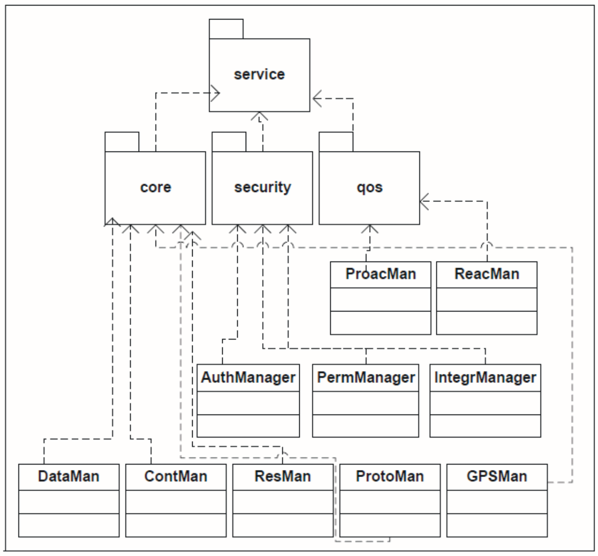

Fig. 3. Class Diagram of Proposed Mobile Middleware

system of existing organ,new ogran monitoring system), we will add servA module in subsections of service,impl and slick. servA in service module will define solution, servA in impl will implements the complement system. .Two instances of servA will be functional inside slick to check its validity. To add a new protocol (security or QoS), we have to adopt the same procedure.

Conclusion

BSN nodes are coming with high capacity of computing complex,sensitive information.Addition of newer products to existing system, giving software support, reuse previous resource- these will be challenging issues in days to come. Advancement of QoS and security protocols of BSN is still in process.Porting middleware to this new change will be also challenging. Interoperability is a concern, but we always need to remember about the limited resouce of BSN nodes.

We have a plan to implement proposed middleware on a testbed.To implement mobility in real sense,we may play with distributed shared object implementation on our middleware. SOAP is one of them and implementing SOAP on nesC over TinyOS will be very challenging.

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