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Resource & Configuration Management for WSN in the Future Internet

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***Abstract*—System resources for WSN need to be efficiently managed & configured. In this paper, we provide an effectual architecture for resource management, provision and configuration for sensor network in the Future Internet schema. Resource management architecture, its modules and mechanism are discussed in this paper and the configuration management is provided as a case study.**

Keywords-Resource Management; Wireless Sensor Networks, Configuration Management,Future Internet.

I. INTRODUCTION

Although technological enhancements promise multi-functional Wireless Sensor Networks (WSN) [1] in the Future Internet environments, however, implemental trends show us that how much resourceful a WSN gets it still cannot be provided with all the required resources. As Unpredicted and Unforeseen events are bound to happen in a WSN. We focus our research on providing a comprehensive architecture for autonomous and intelligent management of WSN in future networks. In this paper we provide an effectual architecture for resource management & provision for sensor network in the Future Internet schema. Resource management architecture, its modules and mechanism are discussed in this paper. Section II discusses some related work, while in section III; we provide our proposed architecture and explanation of its internal components and modules. Section IV discusses the mechanism. Section V provides a Configuration management case study and we conclude our paper in section VI.

II. RELATED WORK

WSNs are more unpredictable than traditional networks. With the deficiency of scarce resources, it is tough to manage them. Management problems of WSN are tried to be solved by many researchers, in which policy based systems [2] have more promising solutions.

Resource management for WSN is not a new issue but recently, the research focus has been shifted to this problem. Some policy based [2] and P2P based system [3] has mentioned solutions to the problem. Some other proposal for resource management are discussed in [4], [5], [6], [7], and [8]. All these proposals have introduced novel ideas for efficient resource management for WSN which are either light-weight or energy-aware. We propose a devisable management system for solving this problem. Our resource management architecture is for WSN in the Future Internet. As all these proposals use different ideologies therefore they are not compared in this paper.

III. PROPOSED RESOURCE MANAGEMENT ARCHITECTURE

For providing a healthier solution, we need Devisable Management, which is a kind of autonomous management where different network managers detects network events and do the necessary tasks based on network resources, predefined policies, intuition and intelligence.

A. Tiny Network Manager(TNM)

For a large scale hierarchical wireless sensor network, TNM resides in the cluster-head nodes. Cluster-head TNM collects and analyzes management data from the cluster members and inter-cluster TNMs communicate each other to handle unforeseen events. However, in a flat WSN architecture, TNM residing in a base station queries other WSNs through the Internet for unforeseen event management. So, we have two separate TNMs, one for a Gateway and other for a sensor node. TNM at the sensor node is used for collecting data and notifying the TNM at the gateway. Fig. 1 shows the TNM which resides at the WSN gateway. TNM at sensor node is a subset of the TNM at the gateway.

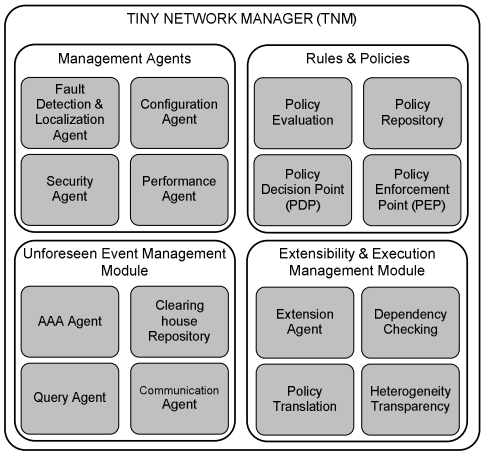

Figure 1: Tiny Network Manager at the Gateway

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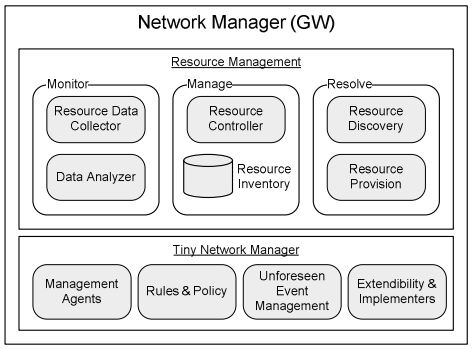

Figure 2: Network Manager at the WSN Gateway composing of TNM and Resource Management Module

Management Agents detect changes in the network (e.g. Anomaly detection) and executes specific management tasks (e.g. configuration management, fault management etc.). Autonomous management can be accomplished with the help of policy based management, which is provided by *Rules and Policies*. It consists of Policy Evaluation, Policy Repository, Policy Decision Point (PDP) and Policy Enforcement Point (PEP). *Policy Translation Module* is an adapter module which is required when the policy syntax or semantics are different for the requester and replier. *Unforeseen Event Management Module* prepares a query to ask about a solution for a specific network state change which is not possible to handle with the existing set of rules and policies. *AAA Agent* is responsible for enabling secure session between WSN gateway, Clearing house and Resource Manager. *Clearing House Repository* holds the identity, location and access mechanism to other clearing houses available on the Internet. *Protocol Extensibility Module* deals with the inclusion, modification and removal of the existing management policies, agents and functions when necessary. *Resource Monitoring Agent* is responsible for gathering the information about the resources at that sensor node and/or the sub-network assigned to that node. *Resource Performance Data Reporting Agent* performs structuring of gathered data and then reports it to the resource management module working at the WSN gateway. *Resource Extension and Implementation Module* is an intelligent module which is responsible for enabling resource fetching, check its dependency and make possible the implementation of that resource in the WSN. *Heterogeneity Transparency module* is responsible for abstracting the heterogeneity in different nodes and networks.

B. Network Manager at WSN Gateway

A modular diagram of the Network Manager at the gateway is shown in Fig. 2, which is consisting of the TNM as discussed earlier (shown in Fig. 1) and the Resource Management Module. *Resource Management* is the basic motivation for the need of the resource management & provision architecture. We can safely say that no matter what technological advancements we get in the near future, the sensor nodes would always required to be resource constraint and efficient, and not powerful enough. So, if we want to increase the functional performance of a WSN, we have to efficiently and intelligently manage the resources. Resource

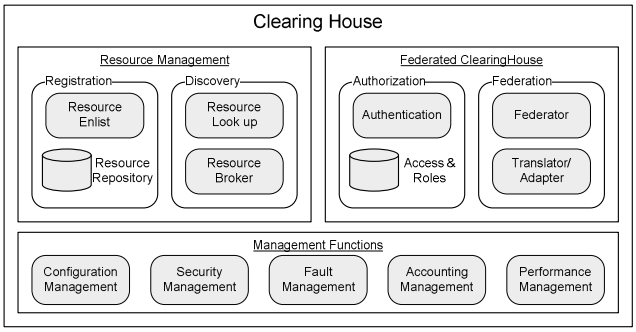

Figure 3: Modular diagram of a Clearing House node

management module monitors the deployed resources at the sensor nodes, manage them if a change or degradation in the resources is found and even look up and provides new and alternative resources to the WSN. To simplify it performs three main tasks:

Monitor: Data Collector module gathers resource parameters information from the sensor nodes and Data Analyzer measures and identifies the degradations in the current resources.

Manage: Resource Controller is the main management entity with resources listed in the resource Inventory.

Resolve: Resource Discovery module is responsible for finding new and alternate resources and the Resource Provision module obtains the resource and implements it in the network.

C. Clearing House

Clearing House is like a service & resource broker, shown in Fig. 3. It provides the location and connection mechanism to the resources, which are registered at the clearing house by one or many resource managers and providers. To expend the clearing house concept, different clearing houses from different provider may collaborate with each other to make a federation among themselves.

Resource Management: All the available resources are registered and maintained in the resource repository by the resource enlist module. *Resource Broker* is the main entity which handles all the resource requests. Resource look up is to find the required resource in the resource depository, where all the available resources are already registered. It provides the resource location and access mechanism.

Conventional Management Functions include the

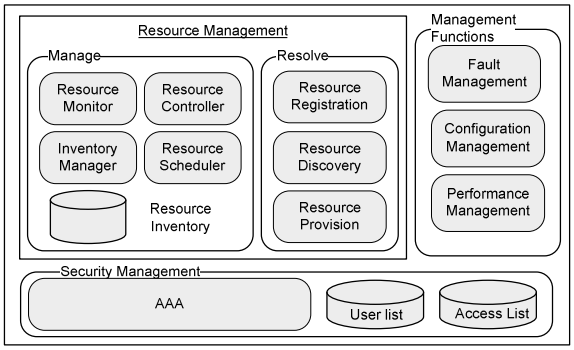

Figure 4: Modular diagram of a Resource Manager

traditional management functions for internal management and assisting in the whole network management.

Federated Clearing House: As there exist more than one CH, they maintain a federation among themselves. If a solution is not found a request can also be send to the federated CH. Federator module is responsible for maintaining federations with the other CHs, while Translation is an adaptor which is required when different CH speaks different protocols. The authorization module entertains the session request and provides authorization and authentication for CH-CH, CH-RM, and CH-Gateway communications.

D. Resource Manager (RM)

Resource Manager is a logical entity that utilizes the concepts of platform & resource virtualization and provides these resources to the needy WSNs. Fig. 4 shows a modular diagram of a Resource Manager. *Resource Management* has two main systems, i.e.

1 - *Manage:* Resource Controller handles the resource requests and performs the task delegation to other modules. Resource registration module registers all the resources at the CH (broker) to make them accessible for the WSN. Inventory manager manages the resources in the resource inventory database.

2 – *Resolve:* Resource discovery looks up the resource, while the resource scheduler performs the scheduling in the case when more than one requests are made simultaneously. Resource provision mechanism is responsible to provide the mechanism by which a resource is reachable.

Management Functions includes the traditional management functions for internal management and assisting in the whole network management. *Security Enabler* entertains the session requests and provides authorization and authentication for CH-RM, and CH-Gateway communications. User list and access list are used for WSN authorized accesses.

IV. Resource Management Architecture

Shown in Fig. 5 is the proposed resource management architecture. When a resource is degraded at the certain node, the TNM at that node informs the Gateway. The gateway in turn looks up for an alternative resource. For that, it initiates a resource discovery. It sends a query to the CH, which looks for such a resource in its resource database. It provides the resource location and access mechanism to the gateway. The gateway sends the resource request to the resource manager, which replies with the resource to the Gateway.

Let's look at this request reply mechanism in detail. First in the resource management module, the resource data collector and analyzer are monitoring the resources. For any reason, degradation in any resource's performance is found. Now, the resource controller looks in its resource inventory for the alternative resource. If there is no solution, then the resolving mechanism is initiated. The resource discovery module connects to CH and sends a resource request. First it uses the AAA module to securely connect to the CH.

At CH the authorization module entertains this request. After a session is established, a resource request is sent to the

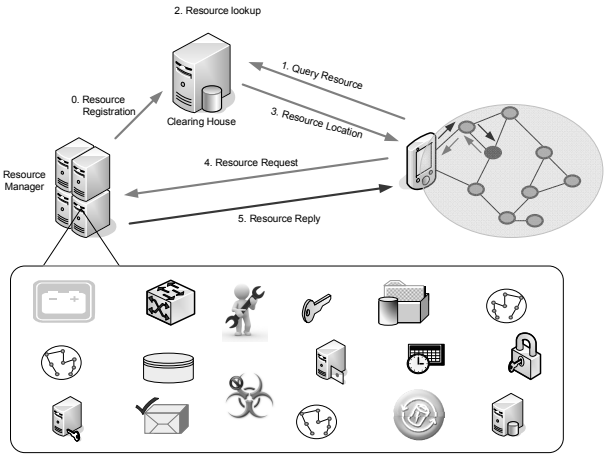

Figure 5: Resource Manager Architecture

Resource Broker at the CH from the resource Discovery at the Gateway. Resource look up is performed to find the required resource in the resource depository, where all the available resources are already registered. If a resource is found, the resource location and access mechanism is provided to the gateway. Now the resource provision module at the gateway connects, again securely, to RM and sends a resource request to the resource controller at the RM. Resource controller entertains the request by delegating the task to the resolving mechanism. Resource discovery looks up the resource, while the resource scheduler performs the scheduling in case more than one request are made simultaneously. Resource provision mechanism is responsible to provide the mechanism by which a resource is reachable by the gateway. At the end, when a resource is received at the gateway, resource provision and extendibility & implementation module performs the necessary task to implement the resource in the network.

V. Case Study: Configuration Management

The main objective of this case study is to evaluate configuration management mechanism for a sensor network. Fig. 6 shows the scenario for the system. As shown in Fig. 6, there is a sensor network consisting of many sensor nodes. These sensor nodes are required to sense the environment and deliver the values to the sink node. The sink provides the basic configurations to each node according to the nodes' application. The different shades of the sensor nodes imply the different application run by each sensor node.

The system is consisted of mainly three sub-systems. One is the server at a PC or Notebook, which is the configuration manager working as the sink node of the sensor network. The other one is the client which may run on the same PC or any other device, providing a remote connection to the server. The third sub-system is an agent which resides at the sensor nodes. This agent is responsible for providing the sensor node application information to the sink node and applying the configuration parameter at the sensor node received from the Configuration manager.

The modular design of the system is shown in Fig. 7. Each Sensor Node has the Configuration Agent, which is responsible for providing the application and node

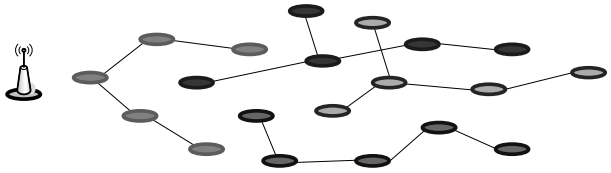

Figure 6. An application aware Sensor Network

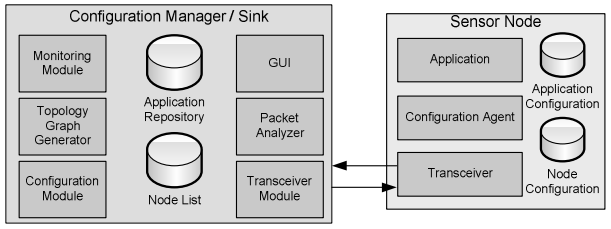

Figure 7. Information Flow and Architecture of the system

configuration to the Configuration Manager (sink node). It is also receives the configuration from the sink and apply them on the sensor node.

The working mechanism of the system is very straight forward. When a sensor node is turned on, it sends it Application information to the sink. The sensor network, using the routing protocol, delivers the message to the sink. When the intermediate node forwards the packet, it appends its own ID. After a defined period of time, when packets from all the nodes are received at the sink, the sink creates a topology graph and visualizes it. According to the number of applications, it creates different sub networks based on application awareness. After that configuration is made it is sent back to the sensor nodes. The Configuration Agent at the sensor receives the message and configures the application and the node accordingly. The mechanism is also depicted in Fig. 8.

According to the application information and network configuration, application aware protocols can be designed or the configuration of the running application can be changed. CM devise new configuration for the sensor nodes and their running applications and creates a response packet for the sensor nodes and unicast them to the sensor nodes.

A. Scenario:

The sensor network is consisted of many nodes. These nodes performing different tasks according to the application they are running. The requirement is to change the values of certain configuration attribute at the sensor nodes such as the threshold value for the alarm, or the change in the sink ID etc. In such a case, the configuration manager sends a SET_VALUE message to the sensor node to change the value or assign a value to an attribute in the sensor node.

VI. CONCLUSION

Implemental trends show us how much resourceful a WSN gets it still cannot be provided with all the required resources. As Unpredicted and Unforeseen events are bound to happen in a WSN. We focus our research on providing a comprehensive architecture for autonomous and intelligent management of WSN in future networks. We extend our architecture to handle such events, provide solutions and fetch resources to implement the feasible solutions. We implemented a part of our architecture i.e. configuration management for the sensor network and discuss it as a case study.

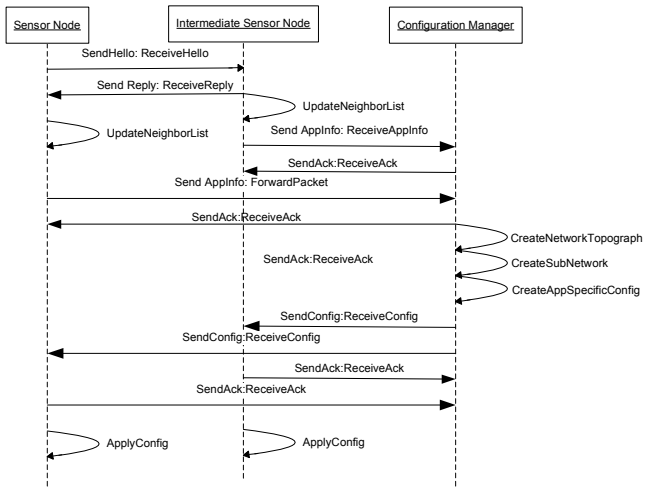

Figure 8. Sequence of message passing between the sensor nodes and the configuration manager.

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