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Self-healing for Autonomic Pervasive Computing

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ABSTRACT
Self-healing is one of the main challenges to growing autonomic pervasive computing. Fault detection and recovery are the main steps of self-healing. Due to the characteristics of pervasive computing the self-healing becomes difficult. In this paper, the challenges of self-healing have been addressed and an approach to develop a self-healing service for autonomic pervasive computing is presented. The self-healing service has been developed and integrated into the middleware named MARKS+ (Middleware Adaptability for Resource discovery, Knowledge usability, and Self-healing). The self-healing approach is being evaluated on a test bed of PDAs. An application is being developed by using the proposed service.

Keywords
Autonomic computing, Pervasive computing, Autonomic pervasive computing, self healing for pervasive computing

1. INTRODUCTION
Pervasive computing environments[1] focus on integrating computing and communications with the surrounding physical environment for making computing and communication transparent to the users. Systems that have the ability to manage themselves and dynamically adapt to change in accordance with policies and objectives are termed as autonomic computing. This system enables computers to identify and correct problems often before they are noticed by the user. Autonomic systems have the capability to self-configure, self-optimize, self-protect, as well as self-healing. Systems that have these characteristics are termed as self-managing systems. Autonomic pervasive computing [2] maintains characteristics from both autonomic computing and pervasive computing environment. Like pervasive computing, devices running in this area should be context and situation aware and these devices form an ad-hoc ephemeral network. These devices are also expected to have the ability to self-optimize, self-protect, self-configure, and self-heal.

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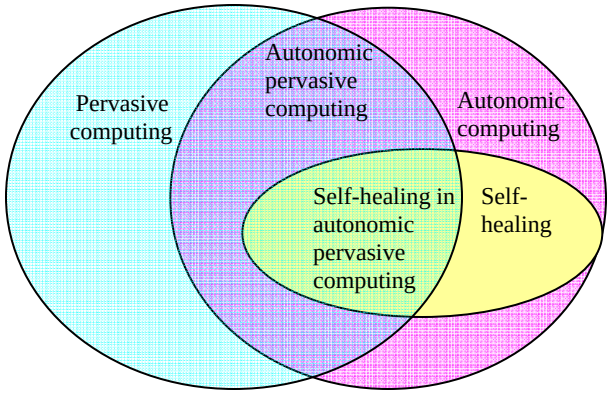

Figure 1. Scope of self-healing in autonomic pervasive computing

Self-healing describes devices or systems that have the ability to perceive those are not operating correctly and, without human intervention, make the necessary adjustments to restore them to normal operation. The concept of self-healing goes beyond fault tolerance since it also provides the device with the capability of recovering from fault by itself or with the assistance of other devices present in the network. Fig. 1 depicts the scope of self-healing autonomic pervasive computing.

Fault tolerance in distributed dependable real-time system has been addressed in [5]. Some solutions along with prototype for pervasive computing fault tolerant systems have been proposed [6]. Self-healing autonomous systems are also addressed in [4, 7]. There has been no solution for a self-healing system in autonomic pervasive computing. In this paper, we present the challenges of a self-healing and outline a model for self-healing for the autonomic pervasive environment, where we assume that the mobile devices would be able to handle necessary computations and communications by themselves without any fixed infrastructure support. We are developing its first prototype on a test bed of PDAs, which are connected with short-range ad hoc wireless.

2.0 CHARACTERISTICS OF SELF-HEALING MODEL
A self-healing model targeted for autonomic pervasive computing should have the following attributes:
1. Infrastructure less. No infrastructure support (powerful servers, proxies, etc.) should be required. If the focus is on truly pervasive environments then the model should work independently without any external support as in this environment infrastructure support is not always available.

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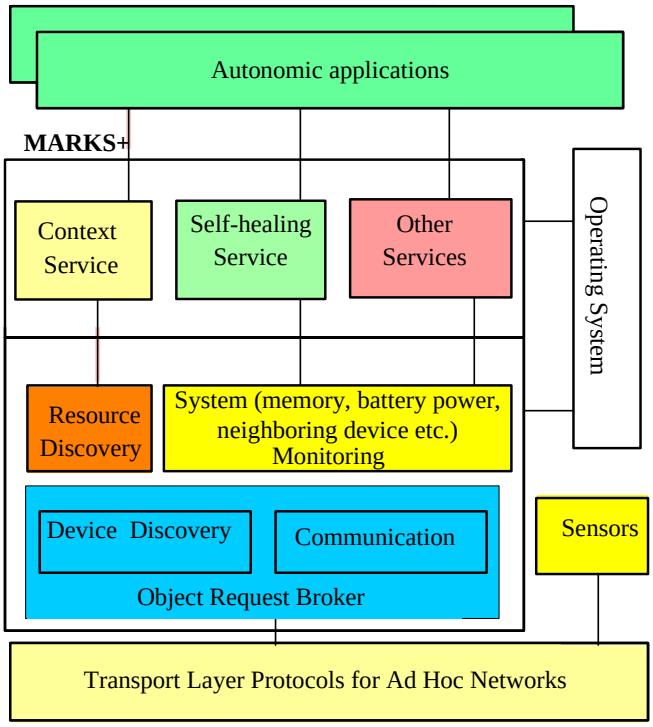

Figure 2. MARKS+ architecture for autonomic pervasive computing

2. Lightweight. The model should be lightweight in terms of executable file size.
3. Non-degradable performance. The model should not put much overhead on the performance of the device.
4. Energy efficient. Self-healing models should be energy efficient. It should not require much battery power for computation or communication purposes.
5. Transparent. The main idea behind designing autonomic systems is transparency. Every self-healing model should have some level of transparency. However, it should also inform the user about critical system information.
6. Secure. Self-healing systems require information distribution and backups to recover from faults. The information distribution and storage should be highly secure to maintain user privacy and security.

3.0 OUR APPROACH

Our self-healing service is an integral part of MARKS+, which is the extended version of MARKS [3] (Middleware Adaptability for Resource Discovery, Knowledge Usability, and Self Healing) which is our developed middleware that incorporates different kind of services. The fault detection, fault notification, and faulty device isolation are taken care of by the healing manager of the self-healing service using system monitoring unit of MARKS+. It uses the system monitoring unit. Figure 2 shows the MARKS+ architecture along with the self-healing service. To address the above challenges in an apposite manner, our proposed self-healing pursues quite a few steps:

a) Fault detection: let *Zt(x)* be the status of a device at time *t*, where *x* represents an arbitrary input vector [e.g. rate of change *(dy/dt)* of power, memory, communicational signal etc. over time]. *T = {v1, v2,… ,vn}* where *v1, v2,… ,vn* are input vectors and *Zt(vi)* represents the status of the device. *T* detects a fault in the device iff *[(Zt(vi) ~Zt+1(vi))> predefined threshold value]*

b) Fault notification: we use a generic message passing scheme not only to facilitate the function of a heart beat message but also the efficacy of an SOS message for helping the healing manager to be informed about the faulty device's current situation.

c) Faulty device isolation: we have deployed a very simple approach to isolate a faulty device from the remaining network. In our approach, each device is mapped with another device based on service availability. So if we can remove the entry number from the mapping list, the faulty device can be isolated from the entire network.

d) Fault healing: the main idea is to store all the crucial information including log status file of the faulty device when the device falls into trouble. After recuperating from a fault, the healing manager re-collects all information and sends it to that device including so that the device can restore easily its previous condition.

4.0 CONCLUSION AND FUTURE WORK

We have proposed a solution using fault detection and notification and faulty device isolation to achieve self-healing in autonomic pervasive computing. Currently, we are developing our self-healing service as a part of MARKS+. In future, we will focus on fault healing. Incorporation of some security features and finding benchmarks for selecting healing manager are also being considered.

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