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モバイル環境におけるIPネットワーク管理フレームワーク

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あらまし IPネットワークが，端末やルータなどノードのモビリティをサポートすることにより，従来有線接続環境を想定して構築されてきたIPネットワーク管理の仕組みを見直すことが必要となる．具体的には，(1)ノードの位置が移動することにより，ネットワーク構成が動的に変化する，(2)ノード間のRTTが大きく変化し，定常的な監視に支障をきたす，(3)端末への到達性の喪失が頻繁に発生し，障害アラートが多数発生する，といった問題が生じる．本論文では，モバイル環境におけるIPネットワーク管理の問題点を提示し，それらの問題点を解決する新しいIPネットワーク管理フレームワークについて述べる．

Framework and Architecture for Management of mobile IP networks

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Abstract Some of the implicit assumptions of traditional IP network management do not hold in networks supporting mobility. (1)The location of a node changes, (2)the RTT between two nodes may fluctuate widely, and (3)unreachability is not a definite symptom of failure. In this work we examine the IP network management issues related to mobility, the information requirements to address these issues and the technology required to make the information available to a manager or management application.

1 Introduction

IP network management has been focused on the basic areas of Fault, Configuration, Accounting, Performance and Security (FCAPS) management. In the traditional management architecture, managers collect management information from agents on network devices. This information is analyzed by the manager to evaluate the status of the network. The manager controls the network by sending directives to the agents.

Close examination reveals that there are two implicit assumptions in network management viz.

- The *location* of a managed device will not change.
- Under *normal* circumstances network devices are *reachable.*

This architecture works well for traditional IP networks. But with the advent of mobile nodes and networks, some of the implicit assumptions underlying traditional network management have ceased to hold. It brings these three difficulties to the management:

- (1)The location of a node changes
- (2)the RTT between two nodes may fluctuate widely
- (3)unreachability is not a definite symptom of failure

In this paper we describes these three difficulties, and proposed the new management framework with location management concept.

2 Problem statement

2.1 Mobility Support Network

A simple model of the operation of mobility supporting IP networks is shown in Figure 1. The entities in this model are *Mobile Entity (ME)* ,

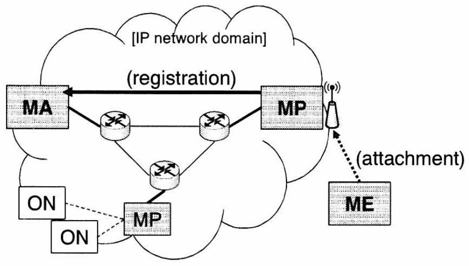

図 1: Mobility supporting IP network model

Mobility Anchor (MA) and Mobility Access Point (MP). MA, a connected device, maintains forwarding information for MEs. ME is a mobility-aware mobile device. In other words it is equipped with a mobility protocol stack. MEs may be integrated with an MP, registered at a MA and can move from one MP to another. MEs may directly register their connection to MA if there is no MP. Other Nodes (ONs) are devices that do not have a mobility protocol stack, e.g. do not support MobileIP. MPs are connected devices which track the IP address of the point of attachment of MEs/ONs and communicate the information to the MA. It may also act as a forwarding destination for ME/ON.

Table 1 shows some mobility protocols in the context of the above model. Our model covers major mobility protocols.

2.2 Location management

The scope of the concept of location in traditional network management has been limited to a static descriptive value of the "sysLocation" object in the MIB-II. But in a network management architecture that supports mobility, the location of a ME may change. This gives rise to a new area of management - *location management*, wherein the location of a ME is monitored, analyzed, utilized and controlled.

Location information needs to be examined closely. There are several components of location information viz. network location, geographical location, organizational location etc. One or more of these will need to be monitored depending on the application requirement. One can envisage that the density, roaming frequency and visit duration of MEs in the network are important pieces of information for planning and designing networks and for configuring mobility related parameters on MA/MPs/MEs.

MEs can roam from network administrative domain to another. Thus the MEs in a network may not necessarily belong to the same domain. On the other hand a ME may not necessarily be connected via a well defined set of one or more known network administrative domains. Thus in the case of traffic monitoring, the traffic from or to a network may be due MEs which belong to other administrative domains. For accounting purposes the network manager may want to have the traffic statistics for each administrative domain separately.

While location has several usages, it may be deemed to be a private piece of information and as such highly sensitive. Access to this information must be carefully considered and controlled.

2.3 Impact of mobility on fault diagnosis

The traditional concept of *reachability* (or *connectivity*) changes in the mobility context. In mobile environments due to the mobility of MEs intermittent unreachability is encountered under *normal* operations.

As a result managers cannot interpret loss of reachability to a ME as a failure of network or the ME. There is also the problem of information hiding. A ME appearing to be just one hop away may actually be several hops away at the other end of a tunnel.

2.4 Impact of mobility on periodical monitoring

Monitoring MEs and applications on the MEs is important. For performance evaluation the change in the monitored statistic with time is of key interest. This requires that every sampled statistic has a corresponding timestamp. The interval of polling in monitoring is generally larger than the response time, so the timestamp of the polling request or the response is taken as the timestamp of the information. The transient nature of the reachability state causes the response time to fluctuate widely. This may cause a severe degradation in the quality of collected information.

3 New management framework with Location Management Concept

We propose *Location Management* as an extension of the FCAPS management framework to sup-

表 1: Overview of mobility related entities in proposed mobility protocols

	Mobility Anchor(MA)	*Mobility Access Point(MP)*	*Mobile Entity(ME)*
MobileIPv4	HomeAgent(HA)	ForeignAgent(FA)	MobileNode(MN)
MobileIPv6	HomeAgent(HA)	-	MobileNode(MN)
HMIPv6	HomeAgent(HA)	Mobility Anchor Point(MAP)	MobileNode(MN)
FMIPv6	HomeAgent(HA)	AccessRouter(AR)	MobileNode(MN)
NEMO	HomeAgent(HA)	-	MobileRouter(MR)
PMIPv6	Local Mobility Anchor(LMA)	Mobile Access Gateway(MAG)	-

表 2: An overview of location management concept.

Fault + Location	Fault must be diagnosed based on a tunnel state and mobility contexts
Configuration + Location	Dynamic location monitoring for location-related MOs must be achieved
Accounting + Location	Monitored devices must be aware of its domains or organizations
Performance + Location	Information must be time-stamped at devices in a periodical monitoring
Security + Location	Management information must be sensitive to its privacy

port location changes of entities. Table 2 shows an overview.

3.1 Fault + Location

Disconnection between manager and MEs is a common phenomenon in mobility enabled networks. Simple 'ping' or polling based failure detection will not work. Network Presence Proxying[1] will lead to misidentifying an intentional power-off of MEs as a device failure. Cooperation with ME-driven notifications and a schedule of connection[2] is also effective. But it is still difficult to deal with sudden disconnection of MEs.

3.2 Configuration + Location

A MEs global address (Care-of-Address) shows its connecting organization or affiliation. This information can be retrieved from registration information available at the mobile terminals anchor point (Home Agent). Among the current published Management Information Bases (MIBs) MobileIPv6-MIB[3] implements "Binding-CacheTable" to support this function. The draft NEMO-MIB[4] proposes an extension of the "BindingCacheTable" and will serve the location information in a similar manner in NEMO(Network Mobility Support, the extension of MobileIPv6) supported scenarios. This is the first step of providing MOs of location.

3.3 Performance + Location

In a network supporting mobility, the RTT may vary widely. The IP level handover time may be as large as *3 secs* [5].

Traditional monitoring processes will suffer from a large number of timeouts. Also a mobile device may be unreachable for long periods of time for example when the device is in a tunnel or in a non-networked zone or because it is switched off to conserve power. An experiment in a real environment shows more than *60%* of data has been lost when polling a mobile device using public wireless access[6]. This leads to data loss in "regular intervals" data collection. To solve this problem, buffering of periodical information at the agent-side is needed. A simple mechanism that uses an information cache at the agent, aggregation and compression in the data collection is presented in [6][7].

3.4 Accounting + Location

Since MEs roam in and out of domains, the traditional traffic data of a network will need to be adjusted for the traffic due to the MEs.

If flow-based traffic monitoring is being carried out, the ME's traffic may be isolated by using IP address information. Information from MPs will be needed to determine which IP address is non-local. Cooperation with other AAA mechanisms will also be needed.

If simple volume based traffic monitoring is ex-

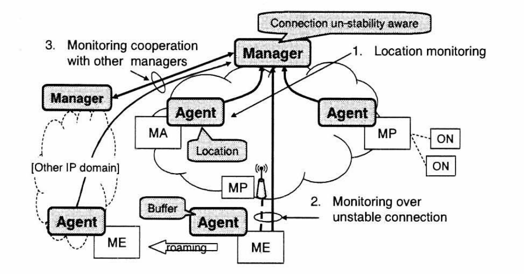

図 2: Basic architecture for monitoring mobility enabled IP network

ecuted, there are two possible methods to get the volume of the traffic due to the *local* nodes and *foreign* nodes separately. First is the separation of traffic based on addresses into *local* and *foreign* devices. Second is the IP header -based traffic classification. ME's traffic has a specific header in some mobility protocol. For example, registration traffic of MobileIPv6/NEMO has a mobility header. It is possible to count those packets.

3.5 Security + Location

Managers may not be able to access MEs from other administrative domains. If there is a trust-chain between local domain and foreign ME's home domain, it is possible to interface with the manager of the ME's home domain and obtain information about the ME. If there is no information about the ME's home domain, MEs should make ACL open for local manager.

3.6 New Network Monitoring Architecture

Figure 2 shows a basic architecture for monitoring in mobility supported IP networks. MA will provide the network location information of an ME. Polling of MEs will be supported by a buffer mechanism implemented in the agent on the ME. The Polling application will be aware of the transient nature of the ME's reachability.

The manager should have a method to cooperate with managers in other domains for monitoring MEs connected to those domains.

4 Conclusions

We have proposed $FCAPS + L$, an extension of the management framework, to support Internet mobility. We examined the management issues related to mobility, the information requirements to address these issues and the technology required to make the information available to a manager or management application.

Acknowledgments

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