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Integrated Satellite and LTE Service Protocols Online Monitoring System Based on Ontology

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Abstract

Integrated satellite and LTE services have large potential market. But suffered from multi-dimensional, heterogeneous in combined environment, large amount of protocols monitor would be long delay and low accuracy. in order to monitor network protocols quickly and stalely, this paper proposes an integrated satellite and LTE service protocols online monitoring system based on ontology. A new monitor base on ontology would be designed to enhance protocols features. Targeted protocols clustering nodes help sparse all protocols into related protocols, which reduces the amount of protocols to be operated. New monitor system improves the delay and accuracy at the same time. Simulations and tests indicate proposed system have 31.2% protocol processing delay and 13.6% accuracy for satellite and LTE environment.

Keywords: *Online monitor, protocol, satellite, LTE*

1. Introduction

With rapid development of global information network, combined satellite and LTE (Long Term Evolution) mobile communications have been significant foundation facilities, which provide with long distance, wide area and high mutual communication services [1].

Thousands of new fused communication services are supported by multi-dimensional, heterogeneous and large amount of protocols in IP (Internet Protocols) layer [2]. For example, in an indoor LBS (Location base service), terminals have to receive information from satellite to cell, from outdoor to indoor, from servers to core network. There are more than 200 species of protocols under operations in IP, about 100MB (Million Bytes) data would be transited in network.

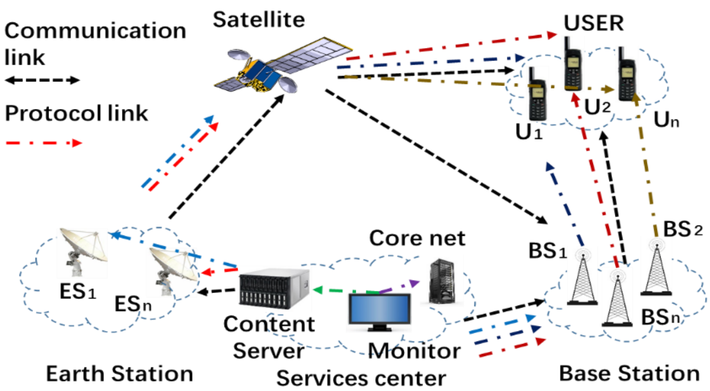

Figure 1. Heterogeneous and Large Amount of Protocols in Satellite and LTE

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Imagine that 100 thousand users exploit LBS at the same time, total throughout of network would be more than 100 TB (Trillion Bytes). What's more, those protocols are from different systems, different network and different users, as Figure 1 shown.

To monitor protocols on line is an efficient way to control and protect network normal operations, which can provide with network real time conditions. Cross layer routing protocol monitor systems were proposed to prevent different layers' protocols translation [3], [4], but a more united monitor architecture for heterogeneous network still need to reduce transforming delay. Congestion control nonlinear discrete networks method had been proposed to solve the problems of protocols translation delay [5], [6], nevertheless ignored satellite network brought in a long delay, would confuse monitor systems by mixture form moment protocols to next moment protocols. Combined bandwidth and network monitoring strategy [7], [8] could enhance accuracy of predictions in heterogeneous network, however, large amount of concurrent protocols might degrade process performance.

Therefore, in order to monitor network protocols quickly and stalely, this paper proposes an integrated satellite and LTE service protocols online monitoring system based on ontology. A new monitor framework base on ontology would be designed to enhance protocols features. Targeted protocols clustering nodes help sparse all protocols into related protocols, which reduces the amount of protocols to be operated. New monitor system improves the delay and accuracy at the same time. Simulations and tests indicate proposed system have 31.2% protocol processing delay and 13.6% accuracy for satellite and LTE environment.

2. Protocols Monitor Framework Based on Ontology

Traditional protocols monitoring systems have to monitor protocol in network. Protocols symbols would be collect and translate into protocol standard processes [9]. All operations would be performed with whole communication. Translations have to wait for all protocols collected, especially in integrated satellite and LTE services, network protocols and LBS protocols would not be separated, which have a poor performance of delay and accuracy.

2.1. Protocols Monitor Framework Based on Ontology

A new monitor framework base on ontology would be designed, which consists of network traffic mirror module, ontology registration sparse module, adaptable data base and decoding CDR module, as Figure 2 show. Network traffic mirror module are designed to collect real time network traffic from target local ports, all data would be copied in mirror server, which ignore running data without any service interference.

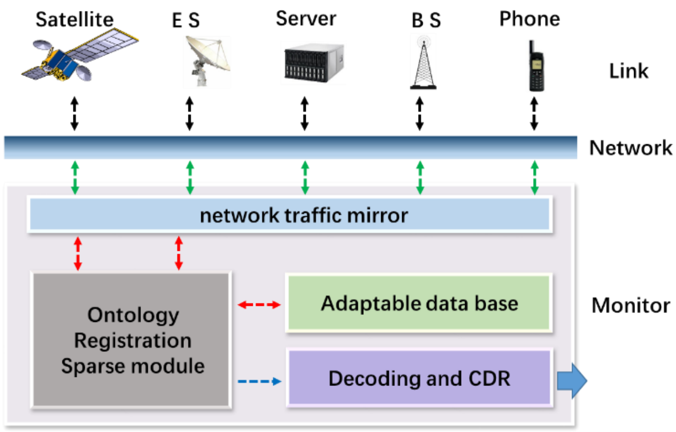

Figure 2. Flattening Protocols Monitor Framework Based on Ontology

Different traditional protocols monitor system, ontology registration sparse module are set into system to flatten the monitor framework, which improve the payload of monitor data. The sparse architecture reduces number of collect protocols by selecting part of protocols features filtered into all traffic. Protocols after simplified would be processed by decoding and CDR (Calling Detail Records). The rules of sparse would be stored in adaptable data base. Adaptable data base is set as a library of filtered and clustering rules, record the protocol specified features after ontology registrations. In next monitor operation, once targeted data traffic are satisfied with the recorded features of protocol in data base, other symbols of target protocol would be collected directly without waiting the end of communication. CDR module is an interface between monitor and users, which presents the whole processes of target protocol in flow chart form. Users can figure out whether the target protocol is running correct or failed.

2.2. Sparse Protocols Feature by Ontology Compression

Ontology compression for protocols is a method to find least features to distinguish target protocol from other protocols, those are essential features. Assume a target protocol is consisted of different features, each feature is presented by different symbols, which extract from reflections effected in network conditions. How to cluster essential features and filter weak relevant features are important for ontology compression to decoding protocols correctly and immediately.

The services in network are assumed as S_n, there are M protocols P_m consisted of service S_n. Each protocol has K different features F_k. Service S_n, protocols P_m and features F_k are defined as ontology entities E_i. Three elements have their own different attributes A_t, for example number, size, time, position and so on. Attributes A_t are subordinate to entities. The relationships between entities and attributes, or between entities and entities are assumed as correlations C_j. Above all, a protocol operation event can be descripted as follow,

$$\begin{cases} E_i = \{S_n, P_m, F_k\} \\ A_t \in S_n, P_m, F_k \\ E_{i+1} = F_{Cj} * E_i \end{cases} \tag{1}$$

In equation (1), we can figure out that each element in entities would be architecture heterogeneous. It's hard to classify entities into attributes, correlations into entities. That's because in a symbols streaming, all data would be transmitted in sequence. So the symbols of entities, attributes and correlations in protocol are exactly groups of data without relationships. Therefore, if there are too many protocols concurrent in network, large number of symbols are easy to collapse monitor systems.

In other to avoid monitoring congestions, sparse protocols feature by ontology compression are design. Ignored the relationship between elements, all entities, attributes and correlations would be grouped in ontology sparse sets according to essential features. Sparse sets are defined as,

$$\mathcal{M}_\ell = \{\mathcal{H}(E_i), \mathcal{H}(A_t), \mathcal{H}(C_j)\} \tag{2}$$

Where, $\mathcal{H}(\cdot)$ represents indifferent normalized calculation. To monitor network protocol would be an operation to find the differentiates from sparse sets of each protocol.

We set target features as F_0, that means once monitor system decoding symbols into F_0, target protocol would be determined. According to Bayes' probability distribution, F_0 satisfy with several regularity:

1) Unique determinacy

A target feature F_0 would determine one protocols, which are one-to-one match.

2) Independent existence

Each target features F_0 of protocol would be independent, which would not affect each other.

Protocols difference are also sparse sets difference, which are defined as ontology distance D_l. Ontology distance D_l can be calculated by correlation operations between each sparse sets. We have to set three parameters to normalize $\mathcal{M}_\ell$, that is

$$\acute{\mathcal{M}}_\ell = \frac{3(\alpha\,\mathcal{H}(E_i) + \beta\mathcal{H}(A_t) + \gamma\mathcal{H}(C_j))}{\sqrt{\alpha^2 + \beta^2 + \gamma^2}} \quad (3)$$

Ontology distance D_l can be calculated,

$$D_l = \acute{\mathcal{M}}_\ell \otimes \acute{\mathcal{M}}_g \quad (4)$$

Whole distance $sum(D_l)$ is

$$sum(D_l) = \frac{1}{2\ell}\sum_{i=0,j=0}^{i=\ell,j=\ell} \acute{\mathcal{M}}_\ell \otimes \acute{\mathcal{M}}_g \quad (5)$$

Therefore, unique target features have most difference from others, whole distance would get the maximum. Take the

$$\frac{\partial \mathcal{M}_\ell}{\partial F_0}|\alpha,\beta,\gamma = \max(sum(D_l)) \quad (6)$$

The maximum 0ntology distance provide protocol monitoring with a certain range, which find exact target features. But we can imagine that ontology distance would be non-uniform, that is, some ontology distances are long, some ontology distances are short. Sparse protocols feature by ontology compression are shown in Figure 3

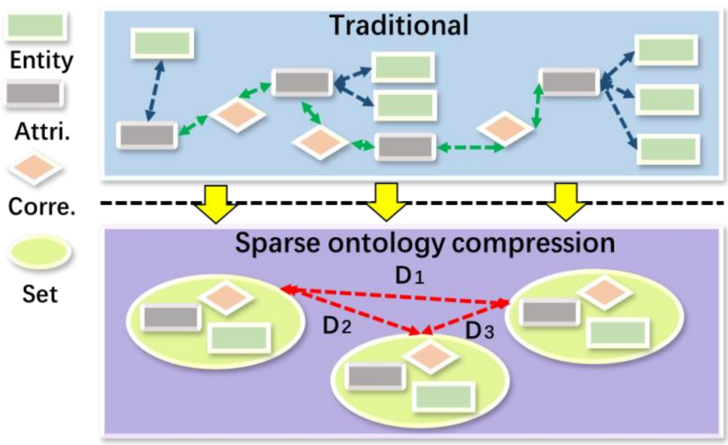

Figure 3. Sparse Protocols Feature by Ontology Compression

The short ontology distances would confuse the accuracy of ontology compression. So sparse threshold D_T is set to control the distances distributions. Mean of Ontology distance are defined as μ_D, we have,

$$D_T > \frac{\ell\sqrt{\sum_{i=0}^{i=\ell}(\mu_D - D_l)}^2}{\sum_{i=0}^{i=\ell} D_l} \quad (7)$$

According to equation (7), only the distances larger than D_T would be considered into sparse protocols feature by ontology compression.

2.3. C. Ontology Compression for LBS

For an indoor LBS, satellite, ES (Earth stations), BS (Base stations) and servers are essential in combined satellite and LTE network. A traditional protocol would be described as Figure 4 shown,

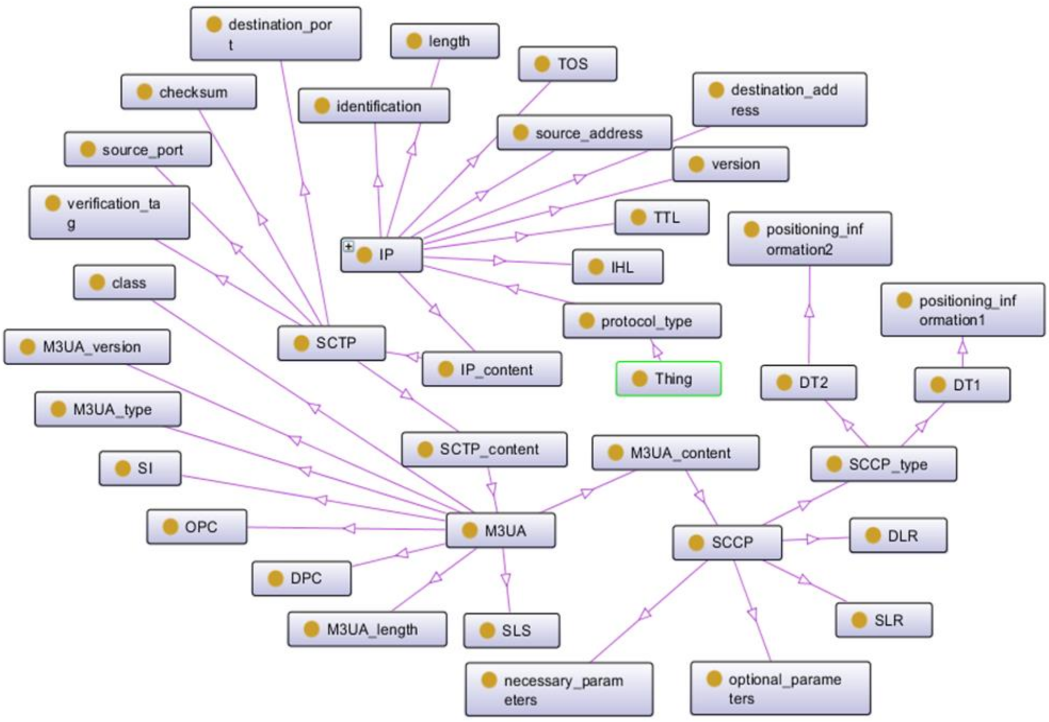

Figure 4. A Traditional LBS Protocol and Relationships

LBS protocols would be simplified into IP, SCTP (Stream Control Transmission Protocol), M3UP (Message Transfer Part 3 User Adaptation) and SCCP (Signalling Connection Control Part), which have different entities, attributes and correlations. According to sparse protocols feature by ontology compression, control parameters would be defined as α_1, α_2, α_3, α_4, β and γ. The Ontology distance D_l would be calculate as Table 1 shown.

Table 1. Ontology Distance Calculation for LBS

Parameter	α_1	α_2	α_3	α_4	β	γ	D_l
source _ address	4	4	0	2	1	0	2.751
destination _ address	4	4	0	2	1	2	2.708
TOS	4	4	0	2	3	3	2.916
source _ Port	3	3	3	3	1	1	2.579
destination _ Port	3	3	3	3	1	4	2.575
OPC	2	2	5	4	1	3	2.430
DPC	2	2	5	4	1	2	2.456
M3UA _ type	2	2	5	4	3	2	3.023
SLR	1	1	8	5	1	5	2.208
DLR	1	1	8	5	1	6	2.674
SCCP _ type	1	1	8	5	3	1	2.416

We can figure out the suitable ontology distances are 3.023, which are the maximum of test protocol monitor.

Therefore, the simplified protocols monitored are perform as follow,

1) Simplified monitoring IP protocol:

-Deleted: TTL (Time to Live), length, version, identification, IHL (Internet Header Length).

-Remained: source _ address, destination _ address, TOS.

2) Simplified monitoring SCTP protocol:

-Deleted: verification _ tag, checksum.

-Remained: source _ Port, destination _ Port.

3) Simplified monitoring M3UA protocol:

-Deleted: class, version, length, SI, SLS.

-Remained: OPC, DPC, M3UA _ type.

4) Simplified monitoring SCCP protocol:

-Deleted: optional _ parameter, necessary _ parameter.

-Remained: SLR, DLR, SCCP _ type.

3. Implement and Test of Online Protocol Monitoring System

The development environment is based on Windows system, with C as development language. ASN.1 (Abstract Syntax Notation) provide monitoring system with symbols translation tools [10]. Oracle database 10 are exploited to store the adaptive rules of sparse. We have network drivers to copy real-time traffic in combined satellite and LTE network. Ontology registration sparse module are designed by database tables and registers. The implement of online protocol monitoring system would be shown as Figure 5.

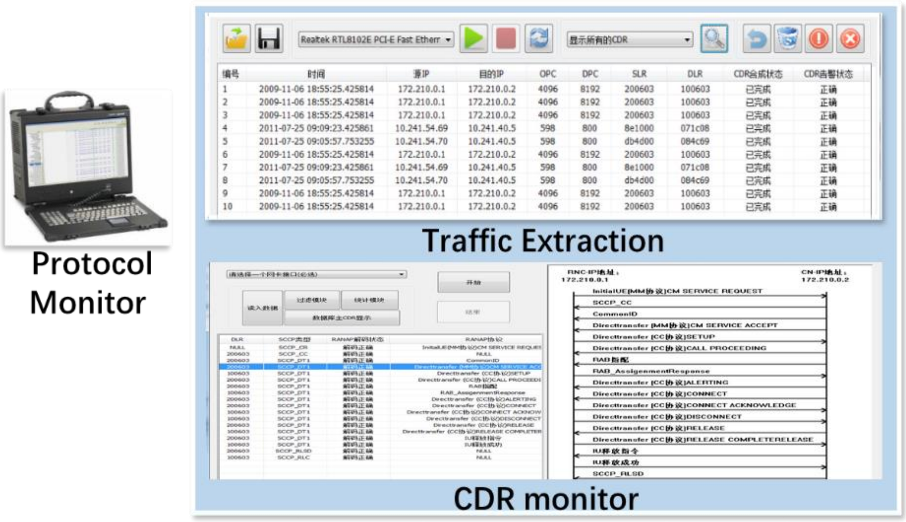

Figure 5. Online Protocol Monitoring System

To monitor the real time protocols operation, we can configuration target port IP address, all protocols would go through monitoring mirror servers. Once observed protocols are selected, ontology registration sparse module would quickly catch a protocol feature, and turn into ontology distance calculation. If ontology distances for target protocol are more than other protocols correlations sum, observed protocol would be determined by the adaptable data base. Without waiting for whole entities caught, online protocol monitoring system realizes rapidly protocol filtered and cluster. After observed protocols are determined, CDR would be presented in protocol window. We can observe the whole protocols process and caught protocols process, the coming protocols would also show in protocol window with grey notations.

The test environments for online protocol monitoring system are also built. Simulated traffic would be serious traffic generated by navigation services in underground parking lot, which contain satellite and LTE communications protocols. online protocol monitoring system would connect into the network with base stations, earth station and core network. Traffic are set 60 minutes last and 384kbps bitrate. Traditional protocol monitoring systems [5-6] also connect into the test network. Three monitoring performance would be collect by Monte Carlo method, the process time and correct probability from three systems are shown in Figure 6 and 7.

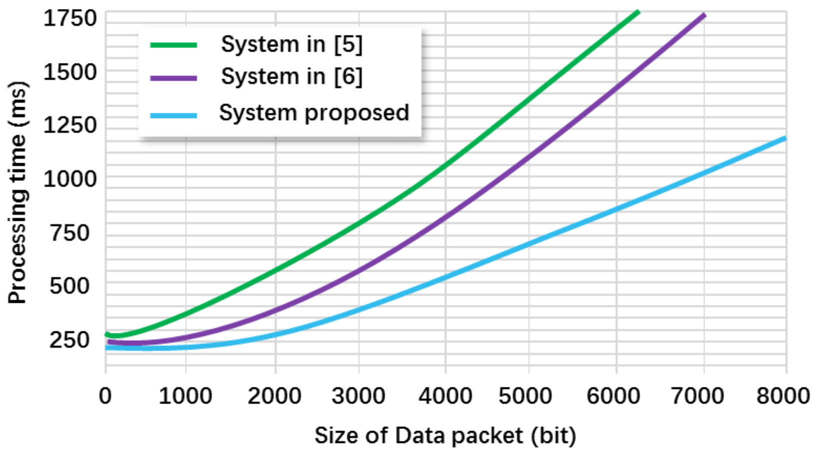

Figure 6. Process Time for Different Protocol Monitoring System

Figure 6 shows process time for different protocol monitoring systems. Assume each navigation service protocol packet is 512 bytes, network load is 58.47Mbps. As number of data packets goes up, processing time of three monitoring systems would increase. Under the same number of data packets, online ontology compression protocol monitoring system have lower process time than other two monitoring systems. when the number of packets is 2000, processing time of proposed systems is 226ms, while systems in [5] and [6] are 334ms and 369ms, have 31.2% protocol processing delay improvement. That's because sparse protocols feature by ontology compression only detect exact target features symbols. We can figure out that online ontology compression protocol monitoring system have much higher efficiency.

Figure 7 shows correct probability for different protocol monitoring systems. The correct probability is obtained as follows:

$$CR = \left(1 - \frac{\sum L + \sum K + \sum W}{N}\right) \times 100\% \qquad (8)$$

L, K, K represent the protocol failed to receive, detect, decoding. As number of data packets goes up, correct probability of three monitoring systems would reduce. Under the same number of data packets, online ontology compression protocol monitoring system have higher correct probability than other two monitoring systems. when the number of packets is 10000, correct probability of online ontology compression protocol monitoring system is 93.2%, which enhance 13.6% accuracy contrast to traditional systems.

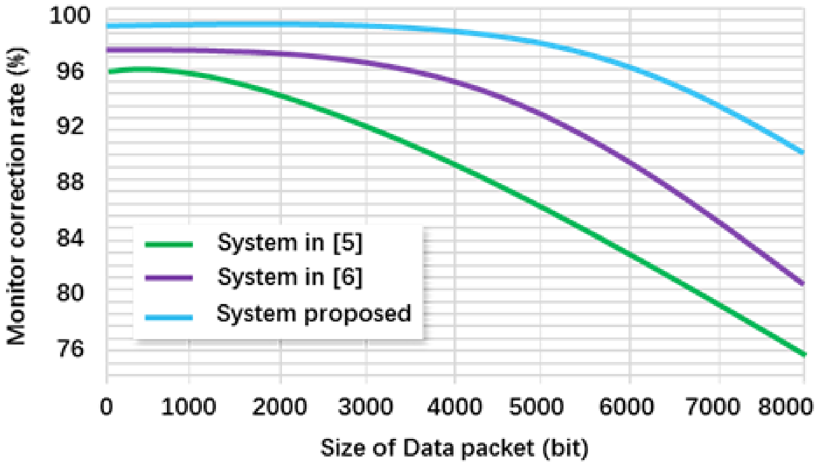

Figure 7. Correct Probability for Different Protocol Monitoring System

3. Conclusions

Integrated satellite and LTE service protocols online monitoring system based on ontology is proposed to solve the poor performance of delay and accuracy. A new monitor base on ontology would be designed to enhance protocols features. Targeted protocols clustering nodes help sparse all protocols into related protocols, which reduces the amount of protocols to be operated. New monitor system improves the delay and accuracy at the same time. Simulations and tests indicate proposed system have 31.2% protocol processing delay and 13.6% accuracy for satellite and LTE environment.

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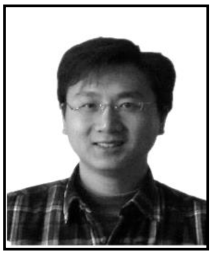

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