EFFICIENT COOPERATIVE INFERENCE INFRASTRUCTURE FOR REASONING AGENTS IN SURVEILLANCE NETWORKS

SOOMI YANG

Department of Information and Telecommunication Engineering, the University of Suwon, Hwasung-si, Gyeonggi-do, Korea.

Abstract- In this paper an efficient and scalable inference infrastructure for surveillance networks providing systematic collection and analysis of social security data based on distributed cooperative ontology framework is proposed. Upon cooperative inference system, each reasoning agent can build and process ontology cooperatively. They share context data for cooperative combined inference. In the process of reasoning agents not only can utilize their own ontologies from a region server but also can form and generate a P2P(peer-to-peer) network to provide ontologies with knowledge data and services to each other in wider bandwidth. For efficient ontology integration the data weighting and similarity measure is incorporated for better caching in information concentric P2P network and shows better performance.

Key words- agent, context ontology, data weighting, surveillance networks, information centric peer-to-peer network

I. INTRODUCTION

In wide area surveillance environment each observation device is equipped with a customized agent. Agents collect data sensed from each devices, extract features from raw data, perform context reasoning to understand present circumstantial situation and derive related judgment. Context is any information that can be used to characterize the situation of environment entities. Ontologies are structured specifications of concepts, properties, and relationships that are required for understanding an area. To get a higher level inference, each agent requires data from other peers. For cooperation between agents, a more efficient and scalable data management framework utilizing P2P computing infrastructure should be established. Each agent tries to be context-aware through integration, analysis and inference of data. For better inference, they need not only data of their own but also data of neighbor agents. P2P computing utilizing information centric network[1] provides efficient ontology sharing method. As a cooperative ontology integration scheme for heterogeneous devices and data network, data weighting with timestamp and similarity measure techniques update and share cached data in efficient and cooperative way. Experiments and implementation are conducted to evaluate the effectiveness of suggested cache scheme. The rest of the paper is organized as follows. Section 2 reviews the related works on information centric network and cooperative inference based on ontology. In Section 3 cooperative inference infrastructure for surveillance networks is suggested. Experiments and implementation are explained in Section 4 and Section 5 concludes this paper.

II. RELATED WORK

Information-centric networking (ICN)[1,2,3] is an approach to evolve the Internet infrastructure to directly support named data as networking principle. Data becomes independent from location, storage, and means of transportation, enabling in-network caching and replication. The expected benefits are improved efficiency, better scalability and robustness. Name-based data access can be implemented on top of the existing IP infrastructure by providing resource naming, in-between caching through trace and corresponding transport services, or it can be seen as a packet-level internetworking technology for Internet routing and forwarding.

Several ontology reasoning systems have been developed for reasoning and querying the semantic web as seen in [4,5,6]. All of them do not utilize ICN for integrated cooperative reasoning based on data communication. Cooperative cache scheme for similar peers is described in [7,8,9], which combines the P2P communication technology with a conventional mobile system. However they do not apply their technique to the cooperative surveillance system. Context inference including distributed multimedia data and feature data is widely used in surveillance including health surveillance as seen in [10].

III. COOPERATIVE ONTOLOGY MANAGEMENT INFRASTRUCTURE

Wide area surveillance infrastructure constructs a web of inference components. Each surveillance data source server is equipped with a local context ontology and reasoning engine. They provide structured and manageable frameworks for modeling environmental knowledge and deriving context awareness. Cooperative inference requires various knowledge for advanced higher level inference based on integrated information and data of neighbors. Our distributed cooperative inference infrastructure manages ontology processing, ontology location and ontology connection on behalf of each agent. Information centric data network is good for data

associations which are required to cover larger areas, monitoring multiple regions or locations. In ICN, agents exchange Interest and Data packet for data acquisition. Requesting agent puts the name of a desired piece of data into an Interest packet and sends it to the surveillance network. Routers use this name to forward the Interest toward the data producers. Once the Interest reaches a node that has the requested data, the node returns a Data packet that contains the data with related information. The Interest and Data packet format is defined as Figure 1 similar to [3].

```
Interest ::= INTEREST-TYPE TLV-LENGTH
                Name
                Selectors
                Nonce
                  Scope
                InterestLifetime
Selectors ::= SELECTORS-TYPE TLV-LENGTH
                 MinSuffixComponents
                 MaxSuffixComponents
                   OrderPreference
                 PublisherPublicKeyLocator
                 ExcludeFilter
                 ChildSelector
                 MustBeFresh

Data ::= DATA-TLV TLV-LENGTH
            Name
            MetaInfo
            Content
            SignatureInfo
              SignatureValue
              DataLifetime
MetaInfo ::= META-INFO-TYPE TLV-LENGTH
                ContentType
                  ContentPriority
                FreshnessPeriod
                FinalBlockId
```

Figure 1. Format of Interest and Data packet

To carry out the Interest and Data packet forwarding, each router maintains three data structures. Pending Interest Table (PIT) stores all the Interests not satisfied. Flooding discovery Interest packet should have lifetime value. Each PIT entry records the data name carried in the Internet. Forwarding Information Base (FIB) is a routing table which maps name to interfaces. Content Store (CS) is a cache of Data packets the router has received. Data packet is cached to satisfy future Interests. Replacement strategy is based on the weight measurement as shown in (1).

The multimedia data and biometric feature information are distributed over the region servers and data source servers. The data source servers need to carry out the indexing and retrieval of the information distributed across the servers. Each data source agent communicates each other within access control. For each data request, data source server n_i sends discovery packet with time to live value.

Forwarding strategy consults weight of cached data. It forwards most similar data with higher priority of higher weight value. Content store of each router acts as a cache for data. It prevents duplicated transmission and reduces traffic by sending cached data.

The similarity measure is the semantic similarity between different ontologies between neighbor agents. For the better inference considering broader area, ontologies of surroundings should be integrated through named data network. They should be merged and aligned according to the semantic similarity. Resulted smaller ontologies help efficient use of network bandwidth and enhance interoperability between agents. Caching in CS also reflects semantic similarity.

There are several measures of semantic similarity[11,12,13]. They use the information content of the shared ancestors or descendants of the two terms. Similarity(concept1, concept2) is the property of the set of distant concepts shared by both concept1 and concept2. As ontology allows multiple parents for each concept, two terms can share ancestors or descendants by multiple paths. Semantic distance is length of the paths. Semantic distance values are analyzed to get semantic similarity measure. To utilize the semantic similarity measures, the values are incorporated into the caching scheme of content store in router.

To have fresh adapted information knowledge, it should be merged, aligned, and integrated continuously. Adapted knowledge base helps inference intelligence and efficient network bandwidth use. The more closely similar two sequences are, the more similar their ontological annotation is. To get the most similar data, the similarity measure should be tested by analyzing semantic similarity.

To maintain the freshness and effectiveness of the data, data in content store should be cached adaptively. The weight of cached data should be measured to describe its relative importance as compared to the other data as similar to [14]. The weight is computed as the product of the access frequency, size of the data, the time elapsed and the number of hops and the similarity measure.

$$Weight = Frequency^{f} DataSize^{s} Time^{t} Hop^{h} SimilarityMeasure^{m} \quad (1)$$

The exponents are weighting factors. As a result, the packet traffic for cached data would be proportional to the probability of cache miss, latency, the probability of packet loss and the inverse of the data

weight measure. Having high weighted data reduces the traffic and improves network bandwidth utilization.

IV. EXPERIMENTS AND IMPLEMENTATION

In cooperative surveillance environment, multimedia data and biometric feature information are produced continuously. Furthermore the multimedia data transmission consumes large network bandwidth. We can efficiently use network bandwidth under information centric overlay network. Further when the proposed adaptive caching technique is applied, it shows better performance.

To implement the proposed ontology integration scheme in surveillance system utilizing context ontologies is built. Figure 1 shows part of user interface. For the integration of ontologies between data source servers, interfaces according to the ONVIF(Open Network Video Interface Forum) standard [15] is implemented. In prototype system, identified events and feature data for context aware computing is structured for similarity measure into knowledge bases. Caching in CS is based on the weight with similarity measure. Web interface as well as mobile interface for administrators and users is developed. Implementation of designing and deploying a surveillance system is to be included in the construction of the ubiquitous city.

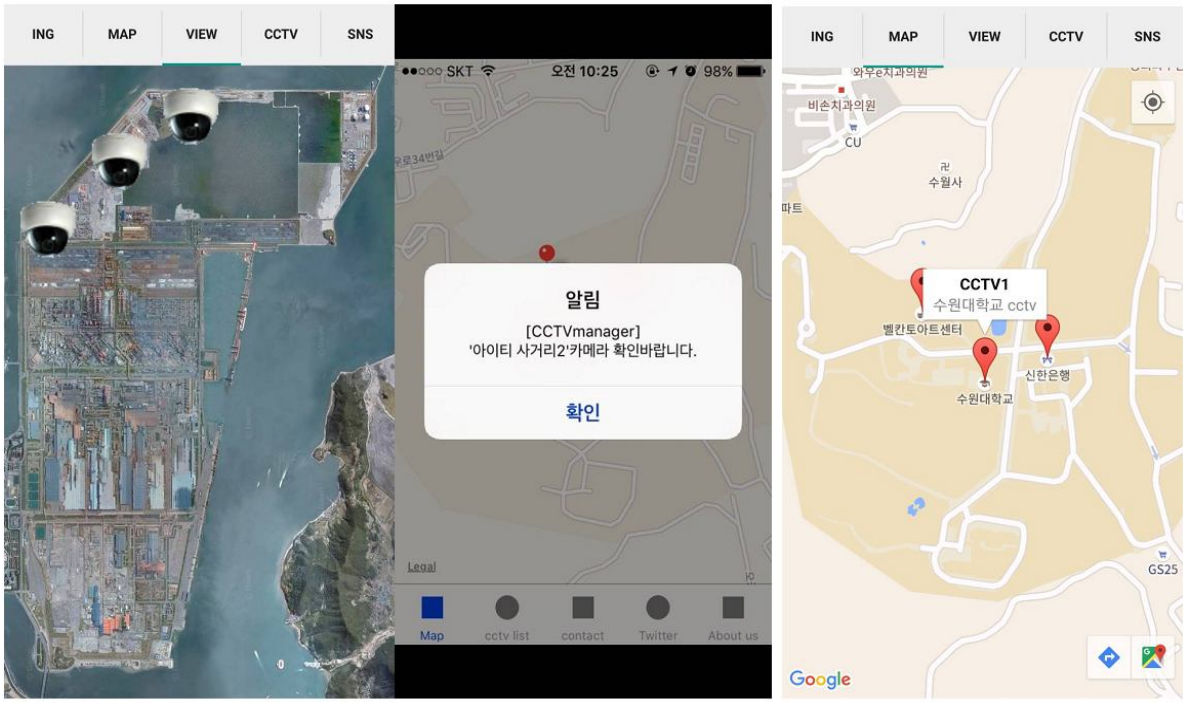


Figure 2. Example of Surveillance system user interface.

CONCLUSION

In this paper an efficient cooperative inference infrastructure for better context reasoning is proposed. Data acquisition servers communicate each other within access control to perform their own intelligent cooperative inference based on integrated ontology knowledge base utilizing information centric overlay network. Data weighing and information similarity measure conformity to update and share data in a cooperative way enhance the data management performance. Cached data in content store reduces the packet transmission and helps the ontology integration efficiency.

ACKNOWLEDGMENT

This work was supported by the GRRC program of Gyeonggi province. [GRRCSUWON2015-B1, Center for U-city Security and Surveillance Technology].

REFERENCES

[1] https://irtf.org/icnrg
[2] George Xylomenos, Christopher Ververidis, Vasilios A. Siris, Nikos Fotiou, Christos Tsilopoulos, Xenofon Vasilakos, Konstantinos Katsaros,George C. Polyzos (2014). A Survey of Information-Centric Networking Research, IEEE Communications Surveys & Tutorials, Volume 16, Number 2, Pages 1024-1049
[3] http://named-data.net/doc/ndn-tlv/, http://www.ietf.org/proceedings/interim/2015/01/13/icnrg/slides/slides-interim-2015-icnrg-1-7.pdf, Alex Afanasysev (2015). NDN Packet Format Specification
[4] A. Flahive, W. Rahayu and D. Taniar (2005). A Distributed Ontology Framework in the Semantic Grid Environment, IEEE 19th International Conference on Advanced Information Networking and Applications (AINA'05), pp. 193-196
[5] J. Z. Pan (2007). A Flexible Ontology Reasoning Architecture for the Semantic Web, IEEE Transactions on Knowledge and Data Engineering, Volume 19 , Issue 2, pp. 246-260
[6] Anne Schlicht, Heiner Stuckenschmidt(2008). Towards Distributed Ontology Reasoning for the Web,

IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology, pp. 536-539

[7] L. Yin and G. Cao (2006). Supporting Cooperative Caching in Ad Hoc Networks. IEEE Transactions on mobile computing, Vol. 5, No. 1, pp. 77-89

[8] Zheng, J., Su, J., and Lu, X. (2005). A Clustering based Data Replication Algorithm in Mobile Ad Hoc Networks for Improving Data Availability, Lecture Notes in Computer Science 3358, , Springer, pp. 399–409

[9] Chow, C., Leong, H., and Chan, A. (2005). Distributed Group-based Cooperative Caching in a Mobile Broadcast Environment, ACM Proceedings of the 6th international conference on Mobile data management, pp. 97-106

[10] A. Shaban-Nejad and V. Haarslev (2011). An Enhanced Graph-Oriented Approach for Change Management in Distributed Biomedical Ontologies and Linked Data, Proceedings of the IEEE International Conference on Bioinformatics and Biomedicine Workshops , pp. 615-622

[11] Ballatore, Andrea; Bertolotto, Michela; Wilson, David C. (2012). Geographic Knowledge Extraction and Semantic Similarity in OpenStreetMap, Information Knowledge and Information Systems, Springer, 37 (1), pp. 61-81

[12] Montserrat Batet, , David Sánchez, Aida Valls (2011). An ontology-based measure to compute semantic similarity in biomedicine, Journal of Biomedical Informatics, Volume 44, Issue 1, pp. 118–125

[13] Dheeraj Rajagopal, Erik Cambria, Daniel Olsher, and Kenneth Kwok (2013). A graph-based approach to commonsense concept extraction and semantic similarity detection, Proceedings of the 22nd international conference on World Wide Web companion, pp. 565-570

[14] Paknikar, A., Kankanhalli, M., and Ramakrishnan, K. (2000). A Caching and Streaming Framework for Multimedia, ACM Multimedia , pp. 13-20

[15] ONVIF (Open Network Video Interface Forum) Core Specification version 2.4.2, (2014)

★★★