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Distributed Ontology Integration Model for Cooperative Inference in Context Aware Computing

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Abstract. In this paper, an efficient ontology integration model for cooperative agent framework is proposed. Context aware computing with inference based on ontology investigates distributed entities on surveillance devices such as smart cameras or sensors which may carry heterogeneous data. However, even smart devices have small memory and power capacities which can only manage a portion of the ontology data. In the proposed ontology integration model, each of the agents that are built into devices get services not only from a region server, but also from peer agents with proper access control and data management.

1 Introduction

Context aware computing is indispensable for the construction of ubiquitous surveillance systems. Networked smart surveillance devices provide huge raw sensed data and inferred feature data. The available information is distributed over various information resources. The information resources are heterogeneous in their content, data format, organization, information management and the like. Heterogeneity of the information resources makes their integration difficult. Furthermore content within the information resources is changeable as it is continuously updated and modified. The agents installed in each smart device have constraints with regard to the memory and the power. Therefore the efficient management of their limited resources and the information is required.

2 Distributed Ontology Integration Model

Context aware computing regarding such as location trace requires the cooperation among the sensors[1]. For regional surveillance networks, a hierarchical tree infrastructure of the regional surveillance networks at the regional and administrative level similar to R-trees[2].

Ontology describes contexts such as concepts and relationships about target environment for the surveillance. None of single agent can accommodate the whole ontology. Each agent with a part of ontology forms a distributed graph structure. They can communicate each other freely within access control permission to perform their own intelligent distributed inference based on their own ontology[3]. We intend to refine each of the local ontology groups and then develop knowledge bases by integrating several related neighboring ontologies. The regional surveillance network forms a hierarchical tree structure by administrative level. If the number of children that each non-leaf node is between m and M where $2 \le m \le M/2$, the height of the tree is bounded by $[\log_M N, \log_m N]$ when N is the number of ontology agents. Bandwidth between the agents is regulated by the tree level.

The data source agents need to carry out the indexing and retrieval of the information distributed across the agents in an efficient manner. To aid the task, a communication protocol is defined according to ONVIF standard[4]. As peers exchange information, they can negotiate and utilize caches based on the messages exchanged. For an adaptive cache management, weight of data is measured using $w = \lambda_{ki}{}^{f} \delta_k{}^{s} \mu_i{}^{r} h^d$ where λ is the access frequency, δ is the size of data, μ is the service interval and h is the distance between the agents similarly to [5]. As a result, better utilization of their limited cache space and higher system performance can be obtained.

3 Performance Evaluation

To evaluate the performance of the model, a simulation to count the number of packet transmissions for accomplishing context aware computing is carried out to inspect the effects on the average packet transmission. Fig. 1 shows the expected packet transmission by packet loss p and service interval μ. When the packet loss is small, the difference is small. However, as the packet loss gets bigger, it suffers more increasing packet transmission. When the packet loss is large, the performance can be managed by controlling the caching ratio q and adjusting the network structure.

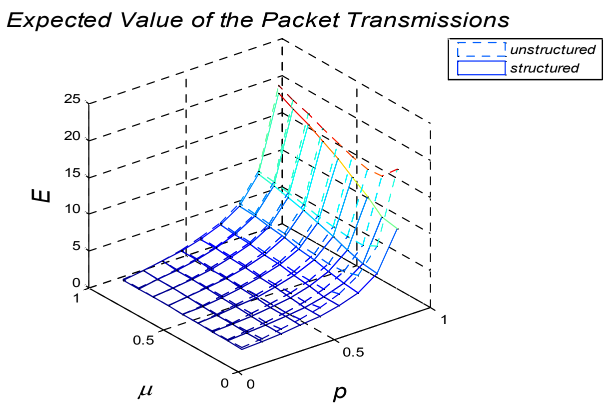

Fig. 1. A comparison of the expected packet transmissions

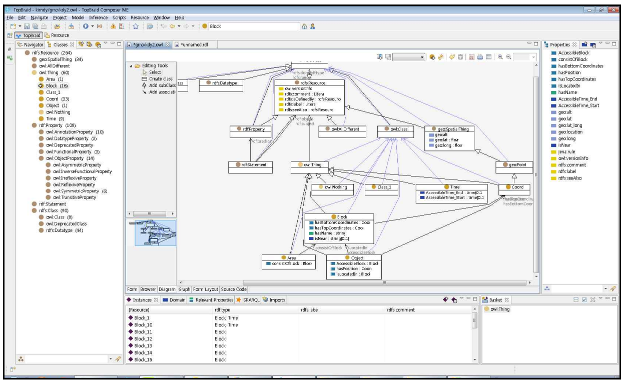

Fig. 2. An ontology description view

Several context ontologies reflecting various types of situation are under development, and the prototype system described in this paper is operated with inference based on ontology integration. Fig. 2 shows a portion of the ontology developed in TopBraid[6]. In the prototype system, surveillance environments are identified for context aware computing into knowledge bases. Final implementation of the proposed ontology integration model will be merged into wide area surveillance system named CUSST(Center for U-city Security and Surveillance Technology)[7].

4 Conclusion

In this paper, the distributed ontology integration model for cooperative inference in context aware computing is proposed. Data source agents exchange information with each other freely within access control in accordance to ONVIF standard. Agents perform their own integrated inference based on their own ontology knowledge base and others. The flexible cache scheme and scalable agent structure which is adaptive to the actual device demands and that of its neighbors help cooperative inference. Context inference including distributed multimedia data and biomedical feature data is widely used in surveillance environment including health surveillance[8]. In [8], biomedical ontologies are integrated in a graph approach. It can be combined with our ontology integration model.

The simulation and implementation are conducted to show the effectiveness of the proposed model. The expected packet transmission is inspected and the trend is analyzed. Realistic data is collected also to make the prototype system merge into wide area surveillance framework.

Acknowledgements

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