

**PROCORE - FRANCE/HONG KONG JOINT RESEARCH SCHEME
COMPLETION REPORT**

Project Reference Number

F-HK25/10T

Project Title

Dynamic collaborative event processing in distributed systems

Particulars

	Hong Kong team				French team			
Name of Project Co-ordinator (with title)	English: Prof. Jiannong Cao Chinese: 曹建農				Prof. Michel Raynal			
Name of Co-Investigator (if any)	English: Dr Bin Xiao Chinese: 肖斌				Dr Achour Mostefaoui			
Institution or Institutional affiliation	<input type="checkbox"/>	CityU	<input type="checkbox"/>	HKU	<input type="checkbox"/>	CEA	<input type="checkbox"/>	INRA
	<input type="checkbox"/>	CUHK	<input type="checkbox"/>	HKUST	<input type="checkbox"/>	CNRS No.	<input type="checkbox"/>	INRIA
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	<input type="checkbox"/>	HKIEd	<input checked="" type="checkbox"/>	PolyU	<input checked="" type="checkbox"/>	University of	Rennes 1	
	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	Others:		
Other project team members (if any)	Weiping Zhu							

Funding Period

	1 st year	2 nd year (if applicable)
Start Date	Jan 1, 2011	Jan 1, 2012
Completion Date	Dec 1, 2011	Dec 1, 2012

Objective(s) as per original application

1. Investigate the issues and requirements of dynamic event processing in distributed systems
2. Develop a two-level infrastructure to facilitate both the distributed design and efficient underlying communication
3. Design and evaluate protocols and algorithms for dynamic event processing via the collaboration of dynamically formed groups of nodes

Please attach relevant document(s)

i) Outline of proposed research and results obtained

With the rapid development of wireless communications and mobile networks, event processing in distributed computing faces new challenges. First, the events' occurrences in terms of the time and location are unpredictable. Second, the composite event category varies frequently due to different user requirements. Besides, the frequent failures and message losses in the distributed system have impact on the event processing. These dynamic event characteristics provide new contexts for distributed event processing systems, and call for the design of radically new solutions which cannot be provided by simple extensions to protocols and algorithms designed for traditional event processing systems.

In this project, we aim at designing protocols and algorithms for nodes in a distributed system to collaboratively process such dynamic events. More specifically, we have done the following:

1) We first investigated the issues and requirements of dynamic event processing in distributed systems. Event processing includes several important components: data collection, primitive event detection, event aggregation and event inference. Data collection is the first step of event processing. Primitive event detection directly follows data collection. Based on it, composite events are detected and processed mainly by event aggregation and event inference. Event aggregation deduces high-level events from low-level events according to the relations included in the composite events. Event inference is another method to achieve event detection and processing. Due to the complex network environment and user requirements, some events may not be directly detected but can be inferred from other related events. Efficiency and reliability are two important targets in all the processing steps.

2) With these requirements, we designed a two-level infrastructure to facilitate both the distributed design and efficient underlying communication. We decoupled the underlying communications and the upper layer distributed algorithm design. On one side, the developers design distributed algorithms with abstract network communication features. On the other side, the developers focus on efficient communication implementation.

3) Based on these, we designed protocols and algorithms for solving some important problems in dynamic collaborative event processing. We proposed an algorithm for energy-efficient event aggregation in the context of multiple events which are with different latency constraints and aggregation functions, and also an algorithm for fault-tolerant RFID reader localization where the detection of RFID tags are used to infer the location of RFID reader. We also proposed methods for event detection in other contexts like WSN-based structural health monitoring and P2P computing.

ii) Significance of research results

Event processing is an important function in distributed systems and can help extract useful information from the event streams, hiding the low-level details and providing high level abstractions to the upper level applications. It is much more challenging due to the widely use of wireless communications and mobile networks where the events to be detected are mostly dynamic and composite. The research conducted in this research project contributes to identify and solve the problems of this topic. Several approaches are proposed for some important specific problems, including event aggregation and event inference. We achieve energy-efficiency of event aggregation and detection when there are multiple events with different latency constraints and aggregation functions. We also considered processing in an environment where system components like nodes and links, and sensor data can be faulty. All of our methods improve the system performance compared with using existing approaches and hence work better for distributed systems.

iii) Research output

Several papers are published under this research project:

- 1) Weiping Zhu, Jiannong Cao, Yi Xu, and Vaskar Raychoudhury, "Event Aggregation with Different Latency Constraints and Aggregation Functions in Wireless Sensor Networks", in Proc. of The 46th Annual IEEE International Conference on Communications (ICC 2011), pp.1-5, 2011

- 2) Weiping Zhu, Jiannong Cao, Yi Xu, Lei Yang, and Junjun Kong, "Fault-Tolerant RFID Reader Localization Based on Passive RFID Tags", in Proc. of The 31st IEEE International Conference on Computer Communications (INFOCOM 2012), pp.2183-2191, 2012
- 3) Weigang Wu, Jiannong Cao, Xiaopeng Fan, "Design and Performance Evaluation of Overhearing-aided Data Caching in Wireless Ad Hoc Networks", to appear in IEEE Transactions on Parallel and Distributed Systems (TPDS).
- 4) Xuping Tu, Hai Jin, Jiannong Cao, Song Guo, Long Zheng, Xiaofei Liao, "An Efficient Data Scheduling Scheme for P2P Storage-Constrained IPTV System", to appear in IEEE Transactions on Systems Man & Cybernetics, Part A.
- 5) Md Zakirul Alam Bhuiyan, Jiannong Cao, Guojun Wang, "Deploying Wireless Sensor Networks with Fault Tolerance for Structural Health Monitoring", 8th IEEE International Conference on Distributed Computing in Sensor Systems (IEEE DCOSS'2012), May 16 – 18, 2012, Hangzhou, China.

iv) Potential for or impact on further research collaboration

Event processing in distributed systems is an important problem for many applications. Through this research project, both Hong Kong team and French team have a deeper understanding of this problem and obtained valuable results, which promotes further collaborations. We think that the two-level infrastructure of event processing which facilitates both distributed design and underlying communication is worth further investigations. Since distributed design and underlying communication have different concerns while also affect each other. How to determine the degree of cooperation and decoupling between them is quite challenging. Both two sides have great interests in this issue. We also think a more comprehensive middleware which implements all our proposed approaches is useful for application development and can be another target in further collaborations.