PIAX Service Platform and its Applications

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Background

- Pervasive/Ubiquitous Computing Environment
PIAX: P2P Interactive Agent eXtensions

- Java-based platform that integrates:
  - Multiple P2P overlay network functions
  - Mobile agent features

- Streaming
- Navigation
- Reputation Sharing
- Shopping Assistant
- Recommendation

Various ubiquitous applications

- Multi-Overlay
- Discovery Messaging

Scalable Messaging by P2P Overlay

Flexible Computing by Mobile Agents

Users
Profiles
Reputations
Sensors
Contents
Devices

Agents
Peer
PIAX Structure and Features

1. PIAX Transport (ID/Locator Separation)
   - Flexible and loose coupling of different services
   - Concealing heterogeneity and complexity
   - Scalable handling of enormous data and nodes, and varieties of requirements

2. PIAX Overlay (Multi-overlay Handling)
   - Physical Network
   - Multi-transport
   - Multi-key Skip Graph
     - Range retrieval
     - Range-key Skip Graph
       - Range-to-range retrieval
     - LL-Net
       - Geographical retrieval
     - DOLR
       - Application-layer multicast
     - Flooding + DTN
       - Any kind of retrievals

3. PIAX Agent (Agents, Web Services, ...)
   - Mobile Agent
   - ZigBee
   - Emulation
   - TCP
   - UDP
   - NAT
   - LL-Net
   - Multi-overlay

Security Support (AAA, Encryption, ...)

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The core overlay network implemented in PIAX is based on Skip Graph that can support range-query.

Geographical Key-value Store

- Range-key Skip Graph enables distributed peers to manage location-dependent contents.
Summarized Features of PIAX

• The features of PIAX are:
  – Flexibility (Mobile Agent)
    • Different kinds of services can be cooperated
  – Scalability (Multi-overlay)
    • Many resources and requirements can be handled
  – Tolerance (Multi-transport)
    • Heterogeneous protocols and devices can be federated

Large-scale intelligent services with heterogeneous devices can be realized over wide-area
1 million peers w/ 100 billion data entries

Node discovery by Range-key Skip Graph

Discover peers that manage the required area

Large-scale Key-value Store (Each node manages a certain region)

Retrieve location-dependent contents from the matched peers

User Terminal

Weather Sensor Map

User Movement Histories

Ex.1) Large-scale & Wide-area Data Sharing
Ex.2) Server-less Watching Service by RFID tags

- Mobile terminals with RFID-tag reader collects RFID-tag info and records location
- The mobile terminals are connected via PIAX and share RFID-tag information
- Observers can search RFID-tag info to estimate the location of target person

Other Applications
Presence Management
Notification/Warning Message Delivery
Automatic life log etc.
Ex.3) Sensor Network Federation

Wide-area and large-scale applications

Disaster management

Facility management

Weather observation

Traffic control

Federation among heterogeneous sensor networks require loosely-coupled framework
Federation of Large-scale Sensor Network

Sensor Network Overlay Platform by utilizing Multi-overlay and Mobile Agent

- Constructs a P2P network connecting sinks.
- The user generates a mobile agent, which travels to particular sinks, processes sensor data, and returns the results.
Federation of Large-scale Sensor Network

Sensor Network Overlay Platform by utilizing Multi-overlay and Mobile Agent

- Constructs a P2P network connecting sinks.
- The user generates a mobile agent, which travels to particular sinks, processes sensor data, and returns the results.

Agent data access
Constructs a P2P network connecting sinks.

The user generates a mobile agent, which travels to particular sinks, processes sensor data, and returns the results.
CONCLUSION AND FUTURE PLAN
Relationships of Our Projects

Sensor Network Federation Platform

Live E! Project

X-Sensor Project

Geographical Key-value Store

- multi-dimensional
- & range retrieval

Multi-transport

Multiplexing & range

Mobile-agent

PIAX Framework

Security Support

(AAA, Encryption, ...)

Physical Network

3. PIAX Agent
(Agents, Web Services, ...)

2. PIAX Overlay
(Multi-overlay Handling)

1. PIAX Transport
(ID/Locator Separation)

RFID-tag and
DTN transmission

Watching service etc.
Future Plan: Internet of Things PF

- Unstable Connectivity
- Appliances
- Service Logic
- Stream Data
- Discovery
- Internet of Things Platform
- Heterogeneity
- Conflicction Coordination
- Stock Control
- Watching Service
- Situation-aware Guidance

Things (trillion class)

- Prove cars, mobile terminals
- Sensors
- Dumb Things
- Terminals
- Embedded devices

Real World Services

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Challenging Issues of IoT PF

• Trillion class things should be connected, federated, and operated by service logics
  – Assumption
    • Energy efficiency, data and device management cost, and security must be issues for the platform because of its scale
  – Issue 1) Retrieval of Things
    • Content-centric, 4 dimensional retrieval, zero/self-configuration
  – Issue 2) Encapsulating diversity of Things
    • Things and its transport description, scale-out framework
    • Routing optimization over unstable network
  – Issue 3) Federate and control Things by service logic
    • Real-time in-network handling (e.g., aggregation, complement) of stream data from Things
    • Service logic description and control Things
  – Issue 4) Ensuring security for diversified providers/users
    • AAA: Authentication, Authorization, Accounting
Conclusion

• PIAX: A P2P Agent Platform
  – Integrate P2P structured overlay network and multiple transports with mobile agent platform
    • Flexible and scalable coupling of ubiquitous services with concealing heterogeneity of networks are realized
    • Examples:
      – Large-scale and wide-area data sharing
      – Sensor network federation and its prototype
    • Plan to utilize PIAX framework for IoT PF
  ➢ Please visit http://www.piax.org/en/ for more information.
• When a node has several transports (links), locator should be selected appropriately

Selective Locator for Multi-transport

→ Selective Locator

Network measurement platform

Locator Selection

Locator Availability

Bandwidth consumption

Measurement

Main Locator

Sub Locator

Node A

Availability of other nodes’ locators

Multicast DNS

Node B

Register availability of locators
• Handle a ‘range’ as a key in Skip Graph

Usage examples:
- Discover a provider that covers a certain place as a service area
- Connect and federate intra-resources among the different organizations (e.g., databases, sensor networks)
Realizing a large-scale sensor network is difficult because of its scale and heterogeneity.
Live E! Project

Disaster Management
Science
Education / Agriculture
Facility Management

Applications

Multi-Attribute search
Sensor & Overlay
Live E! on PIAX

Data Management

In-Network Data Processing
Multi-Domain Sensor Networking

Live E-root ()
live-e-root ()
live-e-wraper (wrapper.)
weather.twnic (tw.)
live-e.coe.phuket (psu.)
Hadyal (IPV6-CNR-HDY.psu.)
live-e.ru.ac.th (ru.)
live-e.kmd (kmd.jp.)
live-e2.hongo
live-e2.hongo
live-e2.naist (nara.jp.)
live-e.e2.naist (jp.)
live-e.lru.ac.th (lru.)
live-e.e2.naist (psu.)
live.e2.niu.edu.tw (niu.tw.)

Delay Tolerant Network
Embedded gateway

Sensors

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Live E! on PIAX

- Developed an agent for enabling other PIAX agents to connect Live E! sensor stations by SOAP protocol

![Diagram of PIAX Overlay Network with Live E! Agent on PIAX and Live E! Weather Sensor Station]
PIAX-based Sensor Overlay Network Platform

• PIAX can support scalable data management on Federated SNs
  1. Sustainability
     • Sensor agent platform and hybrid overlay network will help to tolerate unstable situations
  2. Scalable data retrieval
     • Structured overlays and multiple overlay networks handling will help to handle distributed sensing data efficiently
  3. Efficient data aggregation
     • Distributed data fusion by overlay roaming agents will help to avoid collecting all raw sensing data

Ongoing projects: Live E! on PIAX, X-Sensor v2
Towards Sensor Overlay Network Platform

Sensor Overlay Network Platform

Federation by PIAx

Sequence of sensing data

Storage/Archive for sensing data

Virtual Sensor

Sensor Network A

Live E!

Sensor Network B

Application

Sequence of transformed data

revised source

aggregated source

transformed source

rule-based deduction

Continuous Query

Source

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