Application Domains & Project Activities

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Examples of Application Domains & Possible Scenarios for Project Activities

Examples of recent and relevant application domains for mobile services/systems and case studies towards possible project activities:

- **Social-aware** resource sharing in spontaneous networks
- **ParticipAction**, crowdsensing and participatory task assignment in smart city environments
- **Vehicular traffic management** enabled by “traditional” and smartphone-based sensing (vehicle2vehicle and vehicle2RSU communications)
- **Middleware for Machine-to-Machine (M2M) communications**, fog computing oriented, for efficiency, locality optimizations, batching/aggregation, edge/fog computing, industrial cloud, and container optimizations (e.g., migration)
Real Ad-hoc Multi-hop Peer-to-peer (RAMP)

**Impromtu interconnection** of fixed and mobile nodes
- Not only to achieve Internet connectivity (Always Best Connected - ABC), but also to support users’ willingness to share contents, resources, and services
- Packet dispatching at application level over *het* platforms
- Management of *non-coordinated IP address spaces*

RAMP supports creation and mgmt of *spontaneous networks*
- *multi-hop* end-to-end connectivity
- Users invoke and offer services (peer-to-peer)
- *APIs* to support development of *new services* in a simplified way

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**Example: Application-layer Multimedia Re-casting**

1) Nodes perform end-to-end *cooperative splitting* of multimedia paths into differentiated segments
   - Lower traffic on intermediate nodes

2) Nodes perform *cooperative monitoring of stream quality* (packet loss, jitter, ...) and *dynamically adapt* flows (priority-based video frame dropping)
   - *fine-grained and per-segment* management to reduce needed throughput close to bottlenecks that are identified at runtime

But also example of federation of *UPnP localities*, …
**Social network aggregation**

Some aggregation services already start to emerge: aggregate *messages, status feeds, content, and friends* from different and heterogeneous standalone social apps

- For instance, significant feature of *cross-posting*

In this approach, users should have multiple accounts to the different social new apps

**Federated social networks**

- Users can communicate across domains with globally unique identifiers (one single account for all social new apps)
- User data portability (as for number portability in cell comms, favors competition and migration between social new app providers)
- Greater scaling and robustness of the overall Social Web
- Important industrial and "strategic" trend supported by relevant players (industries, governments, communities, …)

**Federated Social Networks**

Many related technological standards under discussion and definition: OpenSocial, WebFinger, Salmon, ActivityStreams, PubSubHubbub, XMPP, …

See also [http://www.w3.org/Talks/Deck/identity/](http://www.w3.org/Talks/Deck/identity/)
Social-aware Resource Sharing in Spontaneous Networks

Based on the scenarios and technologies sketched above, to contribute to enable resource sharing (typically multimedia contents) among different localities:

- Localities as domestic islands (UPnP and DLNA devices, experimental home gateways by TIM and CISCO, WiFi Direct connectivity, …)
- Island federation as automated federation based on social metadata dynamically extracted from primary social networking applications via standard protocols
- Unique identity for users
- Content filtering offered based on context and social profile
- …

ParticipAction: Crowdsensing

- Collaboration with NJIT and several Brazilian Universities
- Availability of a good set of Android devices and users for wide-scale living lab (300)
- Monitoring and crowdsensing for smart city
- “Smart” assignments of participatory tasks, also with economic incentives
ParticipAction: Task Assignment

- Determination and experimentation of **smart policies for task assignment**
- (pseudo) optimization of reliability in task execution, latency, and economic cost

ParticipAction: CoVID-19?

- Determination and experimentation of **smart policies for task assignment**
- (pseudo) optimization of reliability in task execution, latency, and economic cost
Cars are relevant example of mobile autonomous sensors and they can coordinate themselves lazily by exploiting wireless communications.

- Cars perform opportunistic sensing in urban environments and maintain local data.
- Collaborative dissemination of metadata based on local decisions.
- Possibility of emerging behaviors to satisfy application-specific requirements (e.g., query completeness, response time, overhead, ...).

Previous Experience with MobEyes (UCLA)

Urban monitoring via vehicular sensor networks that are opportunistic and autonomous.

- Opportunistic encounters of “regular” cars equipped with sensors and P2P wireless connectivity.
- Sensor mobility is of course «not-directed».

Differences wrt WSN:
- Less stringent constraints on memory, storage, and power consumption.
- Wide-scale deployment.

Application scenario:
- Post-crime investigation (e.g., after terroristic attack).
- Cars with A/V sensors.
- Metadata summaries.
Idea of using the same “regular” citizen cars to monitor urban vehicular traffic, in areas with relatively high density (in integration and synergy with existing monitoring systems)

Goals:
- Minimization of traffic jams and global travelling time
- Minimization of pollutant emission
- Maximization of traffic fluidity and municipality-level utility functions

Approach: to exploit sensors already available at vehicles, standard frameworks emerging in automotive area, but also onboard sensors by passengers’ smartphones…

Possible directions for project activities:
- Study, analysis, and simulation tests about standards for vehicle2vehicle or vehicle2infrastructure (towards road side units) communications
- Exploitation and integration of smartphones (sensors + peer2peer communications + comm. towards infrastructure) to the purpose of vehicular traffic estimation
- Employment of peer2peer communications (rather than to a centralized infrastructure server) to harvest, aggregate, and process monitoring data in a decentralized way
- Exploitation of locality principle, evolution of geo-tagged historical data, trust level obtained at runtime by participants, …
M2M Middleware

Middleware for efficient communication in Machine-to-Machine (M2M) applications
- Internet of Things and Cyber-Physical Systems (sensors+actuators) scenarios
- Dynamic identification of localities (clustering)
- Data batching/aggregation
- Efficient integration with (virtualized, global) cloud computing resources
- **Edge cloud computing**
- **Fog computing**
- Distributed machine learning, reinforcement learning, federated learning, …

Use Case #1: Predictive Diagnostics and Optimization of Manufacturing Processes

Failure prevention/prediction and planning of efficient maintenance operations through Machine Learning-enabled techniques

- Not only AI…
- Efficiently interconnected IoT
- Industrial cloud and compliance with standards + best practices
- Edge cloud computing
- …
**Use Case #1: Predictive Diagnostics**

-Industrial cloud
-Compliance with industrial standards and best practices

**Use Case #1: Prescriptive Analytics and Optimization of Manufacturing Processes**

- **Digital Twins** of production plants
- **Automated configuration of manufacturing production lines** (system of systems)
- **Dynamic reconfiguration** of production lines
Use Case #1: Prescriptive Analytics and Optimization of Production Processes

- Optimization of product quality and process efficiency based on soft/hard real-time IoT monitoring and machine learning.

Use Case #2: Virtual and Augmented Reality

- **Virtual Reality (VR)**: Completely digital environment. Fully enclosed, synthetic experience with no sense of the real world.
- **Augmented Reality (AR)**: Real world with digital information overlay. Real world remains central to the experience, enhanced by virtual details.
- **Merged Reality (MR)**: Real and the virtual are intertwined. Interaction with and manipulation of both the physical and virtual environment.
Virtual and Augmented Reality for Logistics

Models visualized to integrate knowledge about the «real system» in real-time

Also storage and tracking of previous history of maintenance interventions

Virtual and Augmented Reality for Maintenance
Concept and approach.

IoTwins is an EU project that will work to **lower the barriers for the uptake of Industry 4.0 technologies** to optimize processes and increase productivity, safety, resiliency, and environmental impact.

IoTwins approach is based on a **technological platform** allowing a simple and low-cost access to **big data analytics*** functionality, **AI services**, and **edge cloud infrastructure** for the delivery of digital twins in manufacturing and facility management sectors.

The approach is demonstrated through the development of **12 large scale testbeds**, organized in three application areas: **manufacturing**, **facility management**, and **replicability/scale up of such solutions**.
Platform and services.

All the IoTwins testbeds share the same methodology, grounded on the concept of distributed IoT-/edge-/cloud-enabled hybrid twins, to replicate complex systems, with the ambition of predicting their dynamics and temporal evolution.

Key elements:

- A full-fledged platform enabling easy and rapid access to heterogeneous cloud HPC-based resources for advanced big data services.
- AI services to simplify and accelerate the integration of advanced Machine Learning algorithms, physical simulation, on-line and off-line optimization into distributed digital twins.
- Advanced edge-oriented mechanisms, tools, and orchestration to support Quality of Service in the runtime execution of the distributed digital twins.

Digital Twins concept in IoTwins
Distributed Training and Control in IoTwins

Testbeds.

**manufacturing**

4 industrial testbeds calling for predictive maintenance services (time to failure forecasting and generation of maintenance plans to optimize costs)

*Wind turbine predictive maintenance | Bonfiglioli Riduttori, KK Wind Solutions*

*Machine tool spindle predictive behavior | FILL*

*Predictive maintenance for a crankshaft manufacturing system | ETXE-TAR*

*Predictive maintenance and production optimization for closure manufacturing | GCL International*
Testbeds.

facility management

3 testbeds calling for identification of criticalities, optimization techniques to provide efficient facility management plans, operation optimal schedules, and renovation/maintenance plans

"Nh, NOU CAMP - Sport facility management and maintenance | Futbol Club Barcelona
"Nh, EXAMON - Holistic supercomputer facility management | CINECA
"Nh, Smart Grid facility management for power quality monitoring | SIEMENS

Testbeds.

replicability

5 testbeds to demonstrate the replicability and scalability of both IoTwins solutions and the former manufacturing and facility management testbeds

"Nh, Patterns for smart manufacturing for SMEs | Centre Technique des Industries Mécaniques
"Nh, EXAMON replication to other datacenters facilities | Istituto Nazionale di Fisica Nucleare, Barcelona Supercomputing Center
"Nh, Standardization/homogenization of manufacturing performance | GCL International
"Nh, NOU CAMP replicability towards smaller scale sport facilities | Futbol Club Barcelona
"Nh, Innovative business models for IoTwins PaaS in manufacturing | Marposs
Edge Computing for IoT Apps: Quality Requirements

Towards the vision of **efficient edge computing support** for “industrial-grade” IoT applications

- Latency constraints
- Reliability
- Decentralized control
- Safe operational areas
- Scalability
1. Architecture modeling
2. Quality support even in virtualized envs
3. Scalability via hierarchical locality management
4. Distributed monitoring/control functions at both cloud and edge nodes to ensure safe operational areas

But also:
- Data aggregation
- Control triggering and operations
- Mgmt policies and their enforcement
- …