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Software-defined and Value-based Information Processing and Dissemination in IoT Applications

S&T Campaign: Information Sciences
Human and Information Interaction

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Research Objective

- **Allow the definition of IoT applications in a dynamic urban operational environments.**
- **Address large volumes of data generated by IoT.**
- **Enable an integrated approach to information filtering & dissemination.**

Example: *At a Festival on the National Mall, there are 4 types of users: participants, vendors, EMS personnel, and security personnel. Participants want information about artists and services. Vendors are interested in knowing participants movements and needs. EMS want to track the number of people gathering in each area to plan for the necessary basic facilities (water, ambulances, etc.) and potential emergency requests. Security, on the other hand, is interested in tracking the occurrence of incidents, e.g. drunk & disorderly, and anomalies, e.g., large vehicles with black or no windows.*

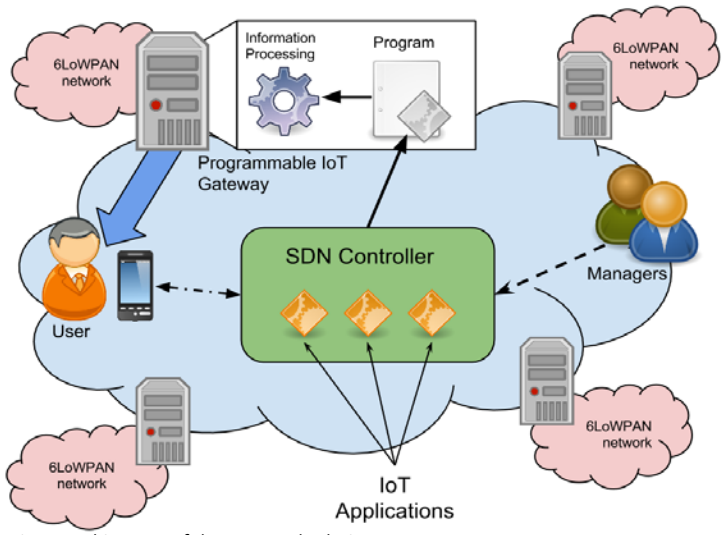

Fig. 1. Architecture of the proposed solution.

Future Challenges

- **Resource and information semantic representation and reasoning.**
- **Adaptive information dissemination solutions.**
- **Distributed SDN controller architectures (more aligned with tactical environment needs).**
- **Refinement of VoI-based information filtering and dissemination.**
- **Extensions to support *Internet of Battlefield Things* for the DoD**

ARL Facilities and Capabilities Available to Support Collaborative Research

- **ALC Campus Sensor Network, for both experimental data and sensor descriptions.**

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Design of middleware for tactical-edge dissemination of content. Ongoing and long-term collaboration with Florida Institute for Human and Machine Cognition (IHMC).**
- **Expertise in Internet-of-Things communications and Software-Defined Networking.**

Relevant Publications

- N. Suri, G. Benincasa, R. Lenzi, M. Tortonesi, C. Stefanelli, L. Sadler, "Exploring Value of Information-based Approaches to Support Effective Communications in Tactical Networks", Communications Magazine, IEEE, ISSN 0163-6804, Vol. 53, No. 10 (Special Feature on Military Communications), October 2015.

IoT Applications: Configuration and Functions

- **Configuration is entered by managers into the SDN controller.**
- **User request a specific "function" among the ones supported (and allowed) by applications.**

```
application "participants", priority: 50.0,
  allow_behaviors: [ :find, :listen ],
  behavior_policy: {
    find: {
      uninstall_after: 2.minutes
      distance_decay: { type: :exponential,
                        max: 1.km }
    },
    listen: {
      allow_processing: :identify_song,
      time_decay: { type: :linear,
                    max: 2.minutes }
    }
  }

application "ems", priority: 90.0,
  allow_behaviors: :all,
  transmission_policy:
    { retries: 3, wait: 20.seconds,
      on_update: :overwrite }

application "security", priority: 100.0,
  allow_behaviors: :all,
  transmission_policy:
    { retries: 60, wait: 10.seconds,
      on_update: :remind_old_value }
```

Fig. 2.a. Example of IoT Application Configuration.

```
find "water"

listen sample: 5.seconds,
  every: 3.minutes,
  processing: :identify_song

track_objects type: :vehicle,
  size: :large, direction: :inbound

count_objects type: :person,
  direction: :inbound
```

Fig. 2.b. Example of fuctions requested by users.

Value-of-Information based Processing/Filtering

- **Use of Value-of-Information based concepts for information processing and filtering.**
- **An information object's VoI depends from the priority of application a (as specified by the managers), the (normalized) number of requests for its corresponding function, the time of origin of the information object, and the proximity of information source with respect to requestor:**

$$VoI(o,r,t,a) = P_R(a) * R_C(r) * T_D(t, O_T(o)) * D_D(O_L(r), O_L(o))$$

Programmable IoT Gateways

- **Programmable IoT gateways can easily take advantage of extra processing capabilities (Cloudlets, neuromorphic processors, etc.).**

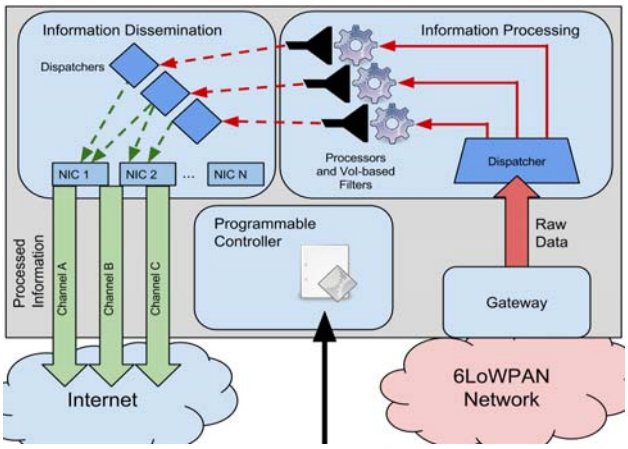

Fig. 3. Programmable IoT Gateway.

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