Real-world Objects and Virtual Objects Management in Cognitive Internet of Things

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Current research in the field of the Internet of Things (IoT) is mainly focused on how to enable ordinary objects or "things" to make measurements themselves in the world around them, as well as connect them to a network for data exchange. The problems of sensor heterogeneity, the lack of functionality of measuring systems/services, and the increase in data generated are becoming obvious to the scientific community.

To address these problem the architecture of cognitive IoT has been proposed [1] (see Fig. 1).

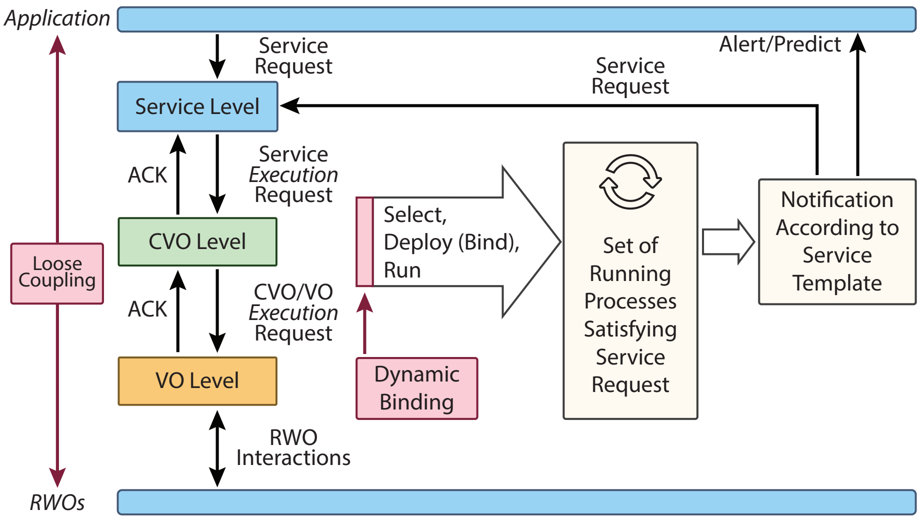

Abbildung 1: Architecture of cognitive Internet of Things.

Functioning of the cognitve IoT architecture begins with the submission of a service request (S_r) at the Service Level. S_r is submitted from a technical or non-technical user of the cognitive IoT architecture. The service request is decrypted into a formal request Q using a function F and a Virtual Composite Object (VCO) is created, which is necessary to fulfill the service request.

$$Q = F(S_r)$$

VCO Level - upon receiving a request from the service level, the VCO management unit searches the VCO registry for an existing VCO that can provide the requested service.

$$S^* = Match(Q, S_i),$$

where S^* is the selected template for the requested service and S_i is the service template from the repository that is mapped by the $Match$ function to a formal request Q.

If such a VCO is unavailable, it searches the VO control unit to find the appropriate Virtual Objects (VO) capable of providing the required functionality in addition to meeting the constraints generated by the query.

$$S_E = L_s(S^*),$$

where S_E is the service execution request for the VCO and VO levels, L_s is the service logic, and S^* is the selected template for the requested service.

The available VCO, $V_{C_{active}}$, is modeled as follows:

$$V_{C_{active}} \subseteq \{\, V_{C_j} \mid Fit(V_{C_j}, S_E) \geq \theta \,\},$$

where $V_{C_{active}}$ is the VCO corresponding to the request, V_{C_j} isis the VCO instance, Fit is the matching function, θ is the threshold.

The VO level receives a request from the VCO level for VO preparation. VOs that meet all the requirements are combined to create a VCO, which can then independently provide the required service.

$$V_{S_{active}} \subseteq \{\, V_{S_k} \mid Supports(V_{S_k}, F_{V_{C_{active}}}) = \text{True} \,\},$$

where $V_{S_{active}}$ is the VO providing the required functions, and V_{S_k} is the VO instance.

The VO layer is responsible for the virtualization of Real-World Objects (RWO), for example, sensors and actuators for any service needs.

The proposed architecture can be used in a number of industrial applications [2] including detection of weeds, classification of wastes, and gas leak detection.

Literatur

[1] Somov, A.S.: Modeling the architecture of the cognitive internet of things for information and measurement systems and automated systems. Trudy MAI. 2025. No. 142. (In Russ.). URL: https://trudymai.ru/eng/published.php?ID=185107

[2] Koshelev, I.; Savinov, M.; Menshchikov, A.; Somov A.: Drone-Aided Detection of Weeds: Transfer Learning for Embedded Image Processing. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 16, pp. 102-111, 2023.