SmartEdge

Semantic Low-code Programming Tools for Edge Intelligence

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SmartEdge Solution

Swarm Concepts and Smart Things

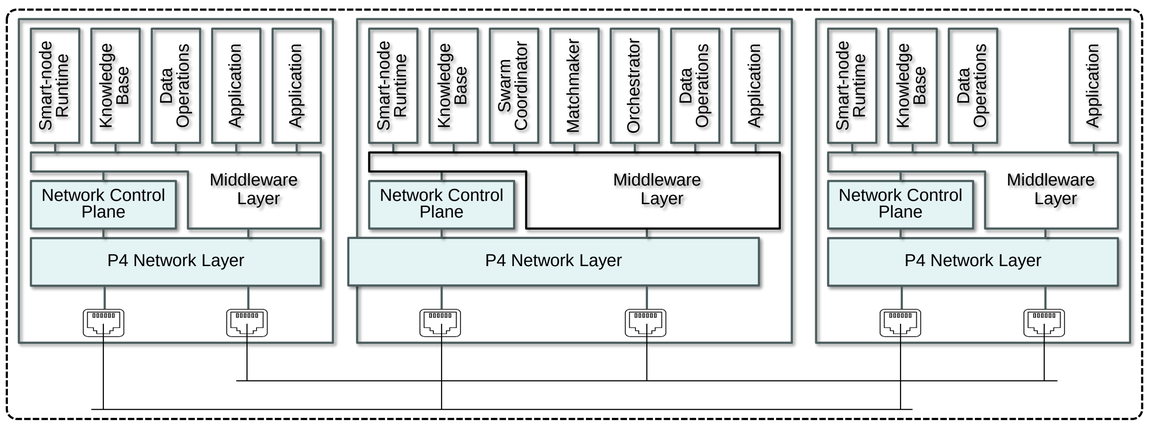
The SmartEdge project seeks to enable the dynamic integration of decentralised edge intelligence, for smart IoT applications, ensuring reliability, security, privacy and scalability. We will realise this via the novel SmartEdge tool-chain for autonomous intelligent swarms featuring real-time semantic integration, discoverability, and composability. To get a sense of what this means, consider a group of people with different roles collaborating on shared tasks.

Each person decides on what actions they will take, based upon their physical senses and what they individually know. People communicate with each other, sending and receiving messages. People may enter or leave the group, as well as switching roles, as and when needed. Knowledge fusion is the process of ensuring that each person has the up-to-date situational awareness needed to make effective decisions appropriate to their roles.

Now imagine replacing some or all these people by software systems – cognitive agents on devices with differing capabilities. Device sensors and actuators replace human senses and muscles. We then need to deal with heterogeneous communication technologies, data formats and protocols. Knowledge graphs provide a representation that hides all that complexity, simplifying application development.

We can model the agents in terms of perception, cognition and action, at a level that builds upon the notion of digital twins. Perception involves progressively higher-level interpretations of sensor data and messages from other agents. Cognition is the process of deciding on what actions to take. Actions include messaging other agents as well as real-time control over actuators, allowing for low-latency control loops.

This approach allows us to consider the swarm as a collection of communicating agents, but we can also consider an agent in terms of the emergent behaviour of an assembly of simpler agents, in what can be termed a hive mind, that is resilient in respect to agents joining and leaving the swarm, resilient to hardware and network problems, resilient to demand spikes, and resilient to cyber-attacks.



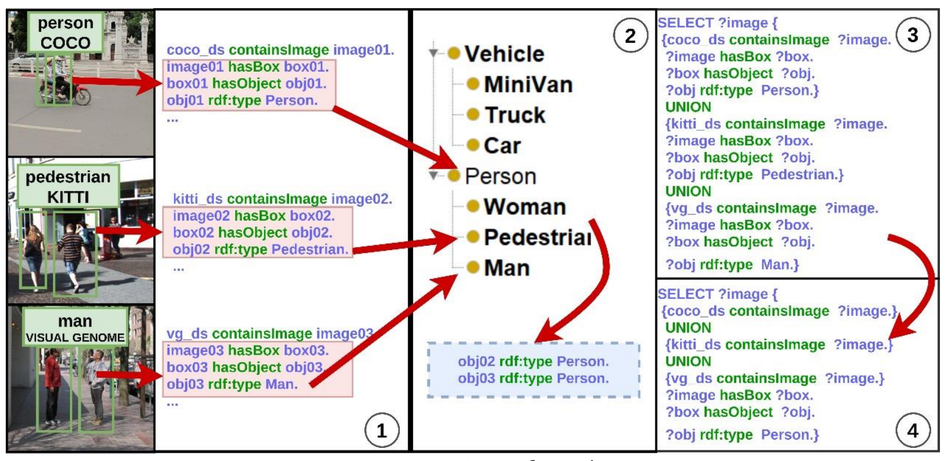


Image courtesy of Bosch

SmartEdge Swarms

SmartEdge defines a swarm as multiple edge devices, vehicles, sensors, robots, etc. that come together to meet one or more common goals. It is designed to support a wide variety of heterogeneous devices and implementation patterns. Whilst clouds can be integrated into the swarm to provide services, they do not directly control it or manage its real-time operation, which is performed by the members of the swarm. Clouds may define the composition and goals of a swarm, but it is up to the members of the swarm to collaborate to achieve these goals.

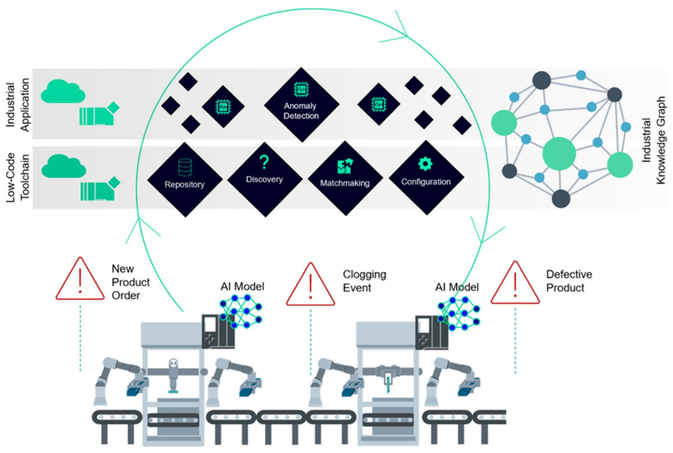
A SmartEdge swarm shares several concepts with object-oriented design (OOD), such as encapsulation and polymorphism. The swarm may consist of members of the swarm, and others that are outside the swarm. In a sense the swarm encapsulates its members and facilitates collaboration between them. Each member of a swarm is a separate entity and can request services from other members of the swarm. The requester specifies the required behaviour, and not how that behaviour is to be performed, similar to the OOD concept of polymorphism. For example, a robot may be asked to move an object, but it is up to the robot how it moves it based upon its physical capabilities, such as grippers, suction cups, etc.

A SmartEdge swarm can operate in two principal modes, either statically defined at design time or dynamically at runtime. It can also provide a service to devices, who request to join the swarm for their own benefit, which could be termed a "Swarm as a Service". For example, a swarm based around a road traffic junction, may be able to assist vehicles in transiting the junction more quickly and safely if they join the swarm. Such a swarm benefits the vehicles whilst allowing the swarm to achieve its goal of more efficient traffic flow.

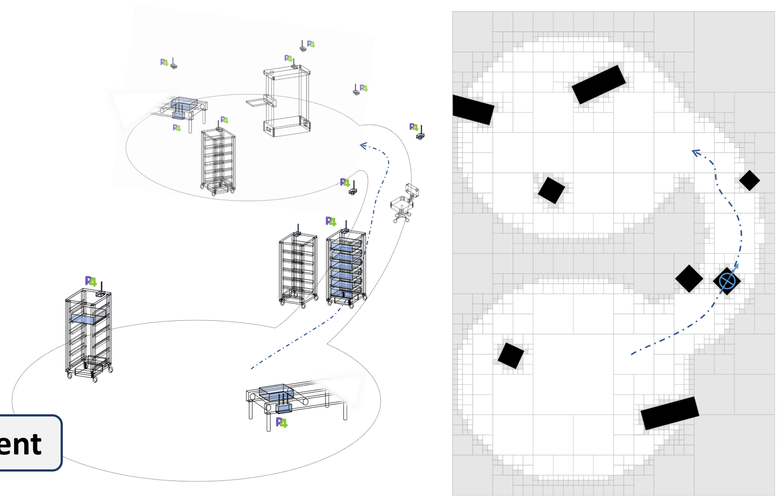
SmartEdge defines several services that are required to perform its core functionality, and mainly utilises the publish and subscribe messaging paradigm with common message semantics. However, it is intended to operate on a wide variety of implementation technologies, which gives the implementer flexibility when deploying the SmartEdge low-code toolchain.

SmartEdge Use Cases

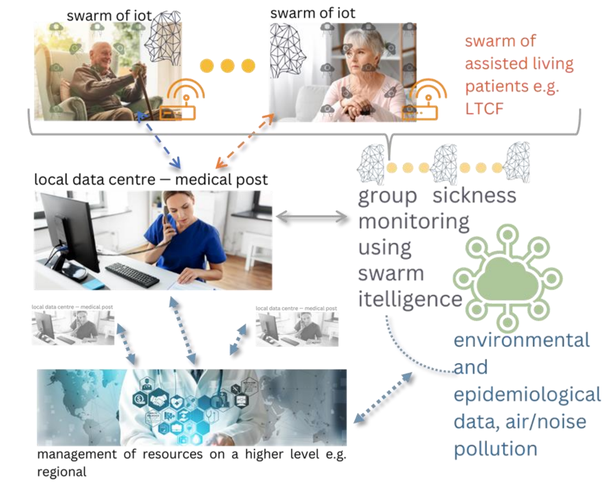
Smart factory with low-code edge intelligence



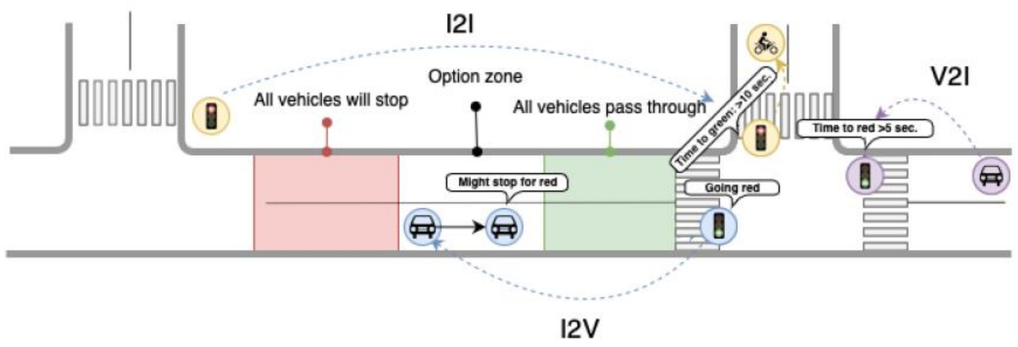
Smart factories with intelligent mobile robots



Edge/Swarm intelligence in health



Active automotive option-zone management



Cooperative perception for driving assist