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Use of collaborative intelligence for knowledge augmentation

CLICK platform

Organizations are harnessing the power of artificial intelligence and machine learning to maximize efficiency and productivity while cutting down the costs. Collaborative intelligence is the key for next generation AI systems. The growing demand for collaborative intelligent devices across multiple applications and domains enables the industry to transition from "weak" AI to "strong" or "generic AI." The use of decentralized architecture in artificial intelligence applications will become more prevalent considering the advantage of collective decision making use of collaborative intelligence.

In AI, the most recent breakthroughs have been limited to individual agents operating in highly constrained environments. Enabling collective knowledge to build dynamics is essential for evolution of AI, this can be achieved by collaboration between AI agents. Adhoc localized networks of collaborative AI agents is an interesting alternative to classical centralized approaches for IIoT. This draws some special properties of problem solving present in social insects, which is flexible, robust, decentralized and self-organized.

Need for collaboration

Current IIoT trends are projecting exponential demand for highly efficient and cost-effective solutions that do not compromise human and machine safety in cloud-denied and internet-denied environments. Most such solutions are "centralized" in nature – require massive datasets, expensive computing resources, periodic tuning and optimization of complex and sophisticated AI agents. At the same time, the design either has multiple identical nodes that provide duplication of identical features, or nodes with varied features and therefore limited capacity. In either case, this poses limitations on overall system capabilities and additional feature duplication cost. Secondly such an architecture is greatly susceptible to central controller's health, failure of central controller essentially shuts-off the entire system.

These operational and environmental limitations can be addressed by decentralized architecture wherein 'hard-wired' nodes are converted to action agents. Now, although each agent has limited local intelligence, multiple agents collaborate with each other offering higher levels of intelligence at system level. This is shown schematically in Figure 1. Such knowledge augmentation from multiple action agents will facilitate to perform designated tasks despite individual constraints (e.g. resources, capabilities, etc.).

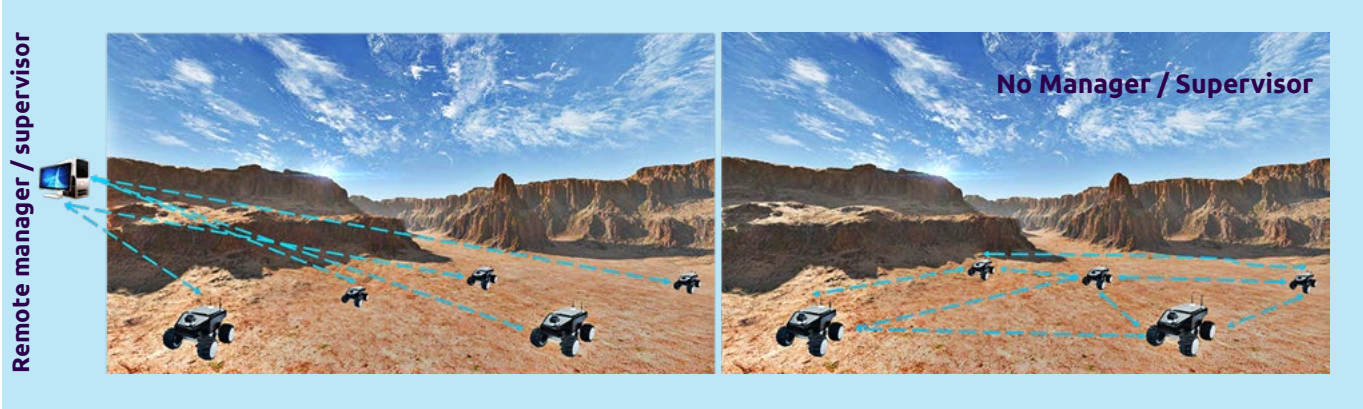

Figure 1: Centralized vs decentralized architecture

Such an architecture will feature:

- High availability (ensuring an agreed level of operational performance) through virtually infinite redundancy (virtual redundancy because there are no additional action agents)
- Democratized intelligence (every action agent functioning independently with local, although with limited intelligence)
- Fault tolerance and smart scale-up
- Faster decision-making

This will ensure high availability of mission-critical control units or action agents in a distributed environment based on decentralized architecture in such a way that failure of any entity does not affect productivity of the system.

A framework that supports such collaboration between multiple agents will boost the overall intelligence capacity of the system. Recent evolution of the IoT as standard, more advanced database architectures (ultra-thin decentralized components with limited but built-in data processing capabilities), rapidly reducing hardware cost and multi-core processors with further increasing processing capabilities, these are some of the factors energizing the development of collaborative intelligence platforms. Such decentralized democratized architecture opens up the possibilities of tapping $550bn of forecasted global business value for smart and intelligent products (edge devices) in the next five years [Gartner, April 2018].

CLICK Platform

CLICK represents **Collaborative Intelligence for Cumulative Knowledge.** It is an architecture as depicted in Figure 2, which provides unique differentiation of the "knowledge augmentation" feature in distributed AI by converting centralized to decentralized AI with no manager or controller having total control. Intelligent agents in such democratic environments are designed to collaborate with each other, perform the designated tasks with more intelligence, and complement each other's constraints / limitations and knowledge integration.

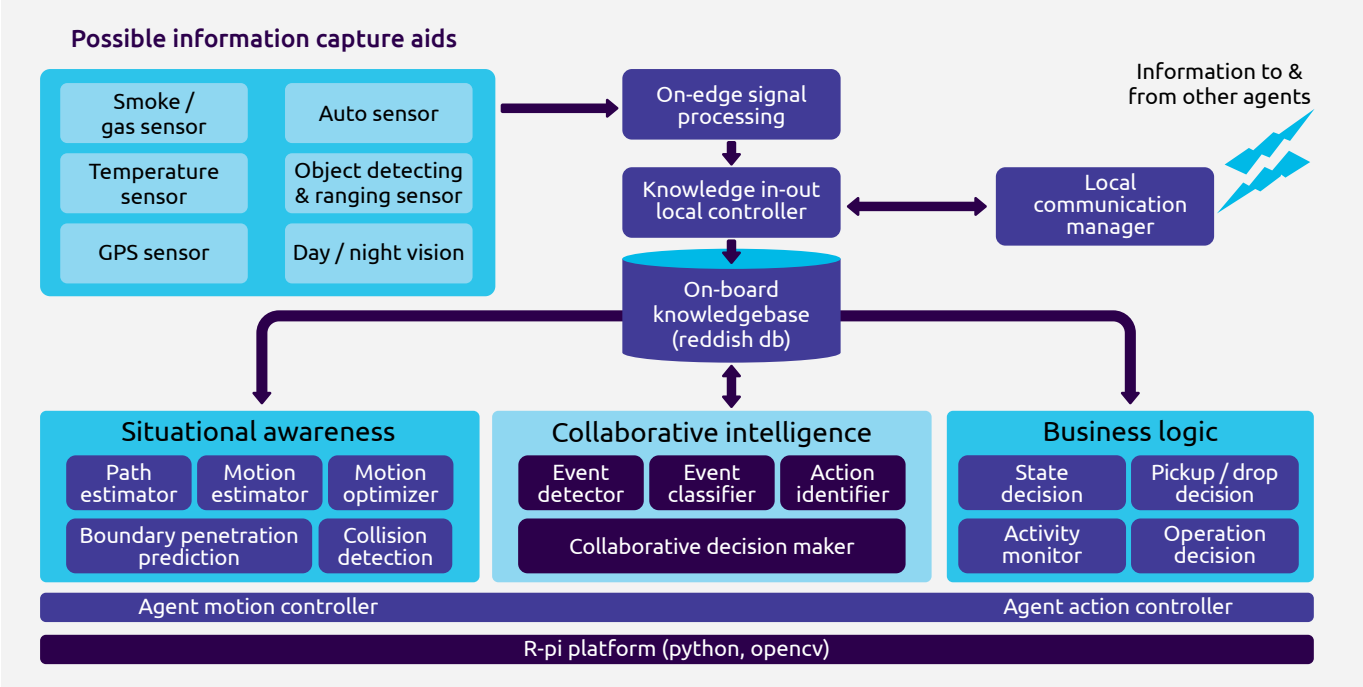

Figure 2: CLICK architecture

Key features of the CLICK platform:

- Limited situational awareness transformed to universal knowledge (amplified awareness) using M2M communication and decentralized architecture
- Thin edge-analytics for real-time information processing and decisions
- High throughput and increased productivity
- Ad-hoc networking architecture ideal for cloud-void, internet-void environments
- Developed using open source tools like Python and OpenCV

Our CLICK platform here is illustrated with a warehouse example involving multiple agents equipped with machine vision and sensors, lightweight edge computing and localized M2M communication through intelligence for real-time operations. This is conceptualized in Figure 3. If one agent fails, the others optimally share the tasks of the failed one with mutual agreement. Another example is if a task appears for a certain agent of which it is unaware, other agent that does have knowledge of that situation alerts the designated agent to switch on to the task. Many such collaborative intelligent situations can be illustrated using a true democratized intelligence – CLICK.

In CLICK, several components enable the enhancement of system intelligence through collaboration, as illustrated in Figure 4. These are advanced analytics and ML algorithms, edge computing technologies, ad-hoc communication networking capabilities, and overall engineering analytics procedures and frameworks.

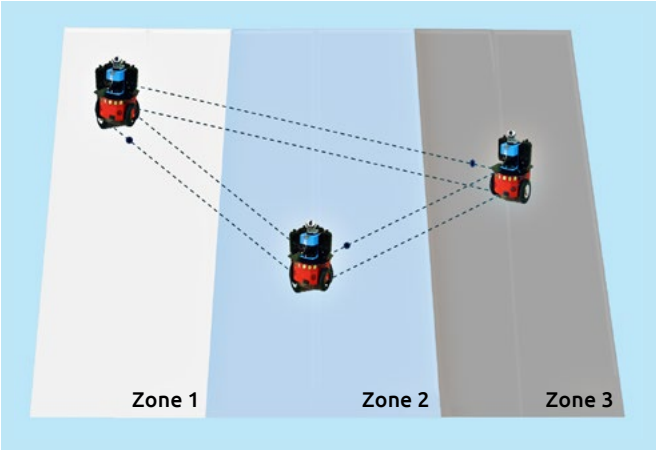

Figure 3: Schematic of CLICK applied at warehouse

CLICK for high availability

This case study consists of multiple agents patrolling the designated zones to transport objects as shown in Figure 5. This is the case in warehouse forklifting, where goods must be carried from the unloading zones to specified stockers. Communication between agents takes place wirelessly via WiFi, based on a Capgemini proprietary communication chain algorithm. The agents continuously exchange health and location status. Equipped with an on-edge machine vision, intelligence is built into every agent using machine learning and cognitive algorithms that provide capabilities for collective, optimal decisions and collaborative operations in the absence of a centralized controller / supervisor.

In the standard operating scenario, whenever an object is detected in a certain zone, the respective agent will approach the object, pick it up and drop it off at either of the ends of its designated zone.

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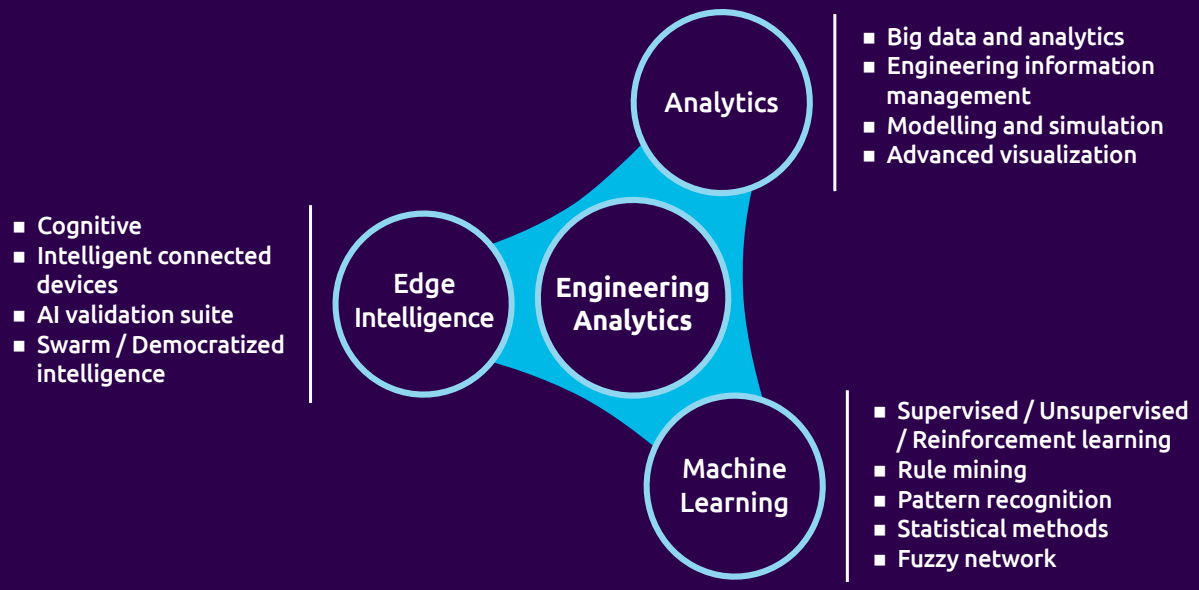

Figure 4: Collective intelligence enablers

However, various scenarios where collaboration becomes a key can arise –

- If an object in zone 2 is not in the line of sight of agent 2, Agent 1 or agent 3 can detect that object and communicate it to agent 2 for necessary action.
- An object that falls within the zone boundary may attract the attention of two agents. Agents mutually make a decision based on which is closer to the object.
- When a certain agent fails, say agent 2, the other two agents communicate and auto-reconfigure their work areas to accommodate the designated zone of agent 2 and continue patrolling accordingly. This is illustrated in Figure 5.
- When a failed agent resumes work, all agents re-provision their work areas and return to normal operation.

Figure 5: High availability illustration using CLICK

CLICK for knowledge augmentation

Knowledge augmentation from multiple agents is illustrated through an example here, if a task appears for a certain agent of which it is unaware due to limited situational awareness, another agent that is aware of that instantaneous situation alerts the designated agent to switch on to that assigned task. These intelligent agents are equipped with an optical camera for generating environment awareness, and have a broader field of view, beyond the self-zone.

Individual agents can only view the workspace on the front side. As depicted in Figure 6,

- Agent 1 cannot see a pending task behind it. However, agent 2 busy in performing its own task and travelling in the opposite direction locates the pending task for agent 1.
- Agent 2 analyzes the situation and immediately shares this knowledge about the pending task with agent 1.
- Agent 1 receives this communication about the pending task and rotates back to locate and complete the task.

Thus, with knowledge sharing through collaboration, agent 1 completes a task which may otherwise not have been completed on time. Furthermore, agent 1 continues travelling and collaborative communications continue enhancing the overall system intelligence.

Theoretically, such an architecture can result in strengthening of intelligence to any required level through integration based on a variety of information capturing aids, degree of collaboration, and number of collaborating agents.

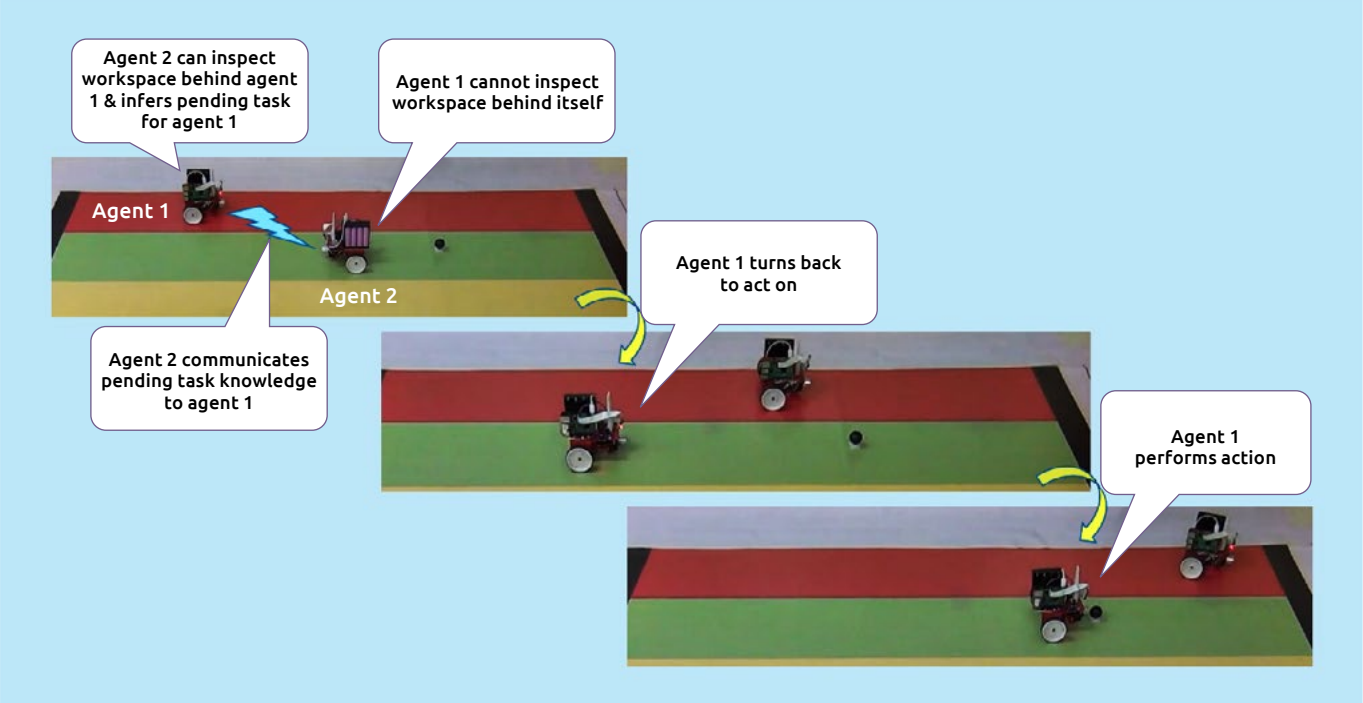

Figure 6: Case of enhanced intelligence through knowledge sharing using CLICK

Conclusion

Many such scenarios can be illustrated showing higher potentials of collaborative mechanisms with a truly democratized / decentralized intelligence. This collaborative intelligence concept is illustrated with a proprietary IP platform – the CLICK platform. Intelligent agents are empowered with local decision-making ability on the device itself (edge computing) through enhanced situational awareness in relationship with each other in the communication chain.

The platform illustrates a higher order of intelligence through M2M communication, distributed intelligence, decentralized architecture, and virtual 1: N redundancy. This low-cost platform is developed on Raspberry-Pi. It supports knowledge augmentation from multiple agents to perform a designated range of tasks in spite of individual constraints like resources, capabilities, etc.

The growing demand for collaborative intelligent devices across multiple applications and domains enables the industry to transition from weak AI to "strong" or "generic AI." The use of decentralized architecture in artificial intelligence applications will become more prevalent considering the advantage of collective decision making using collaborative intelligence. Current IIoT trends are projecting exponential demands of such highly efficient and cost-effective solutions without compromising human and machine safety in cloud-denied and internet-denied environments. The beauty of knowledge collaboration is limitless intelligence and economical for the knowledge owner!

About the author

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Multidisciplinary skills with a unique combination of scientific R&D, academics, and industry profile. Doctoral research in fiber optics and sensors, instrumentation, integrated optics, and modelling & simulation. Spanning over 24+ years of application-oriented R&D and multi-sector industrial experience. Expertise in engineering analytics, automation and control, and advanced intelligent systems. Known for innovative solutioning and industrialization of cutting edge technologies.

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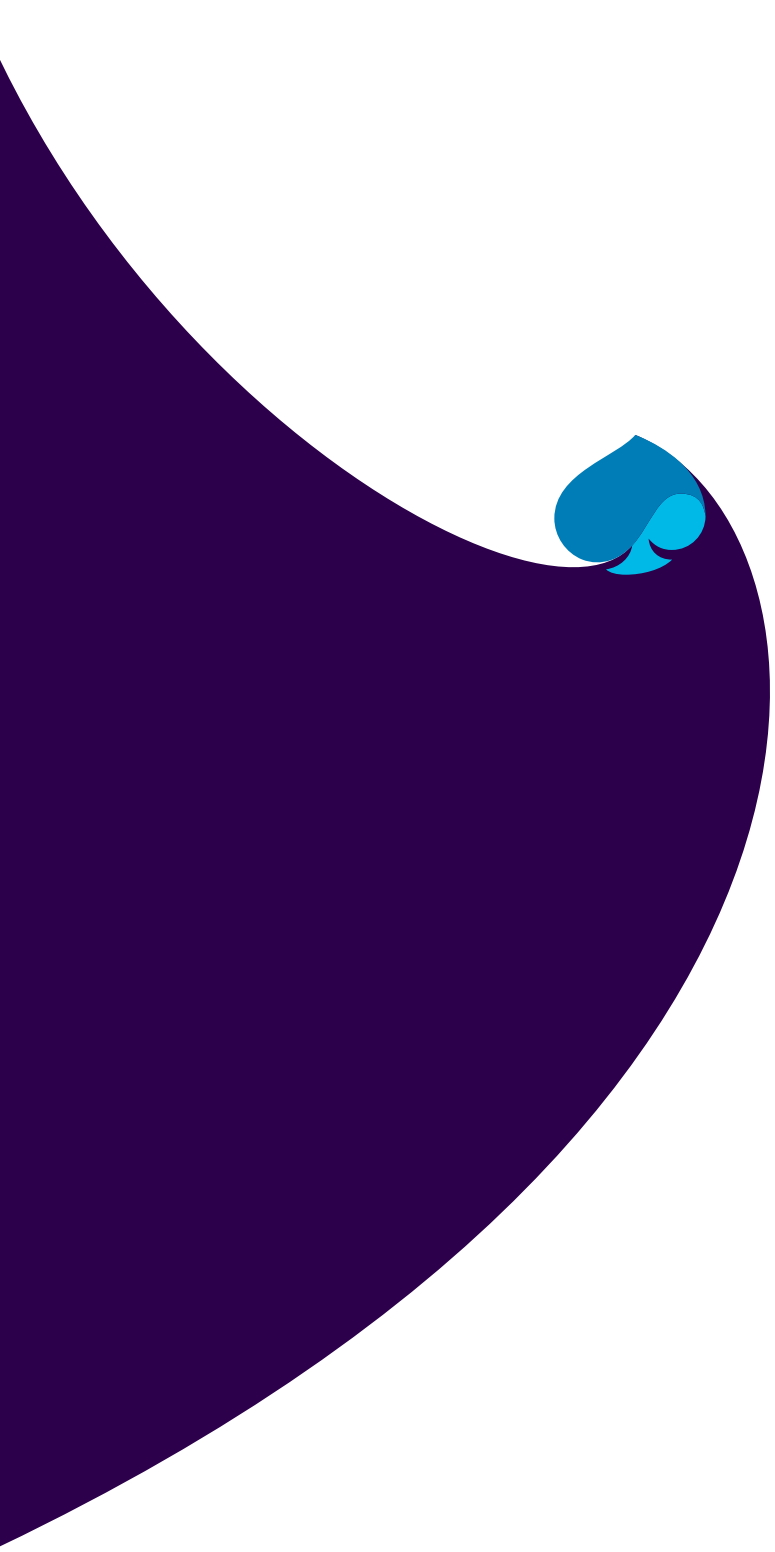

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