Digitalisation for Self-regulated Vehicles via the Internet of Things

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Introduction

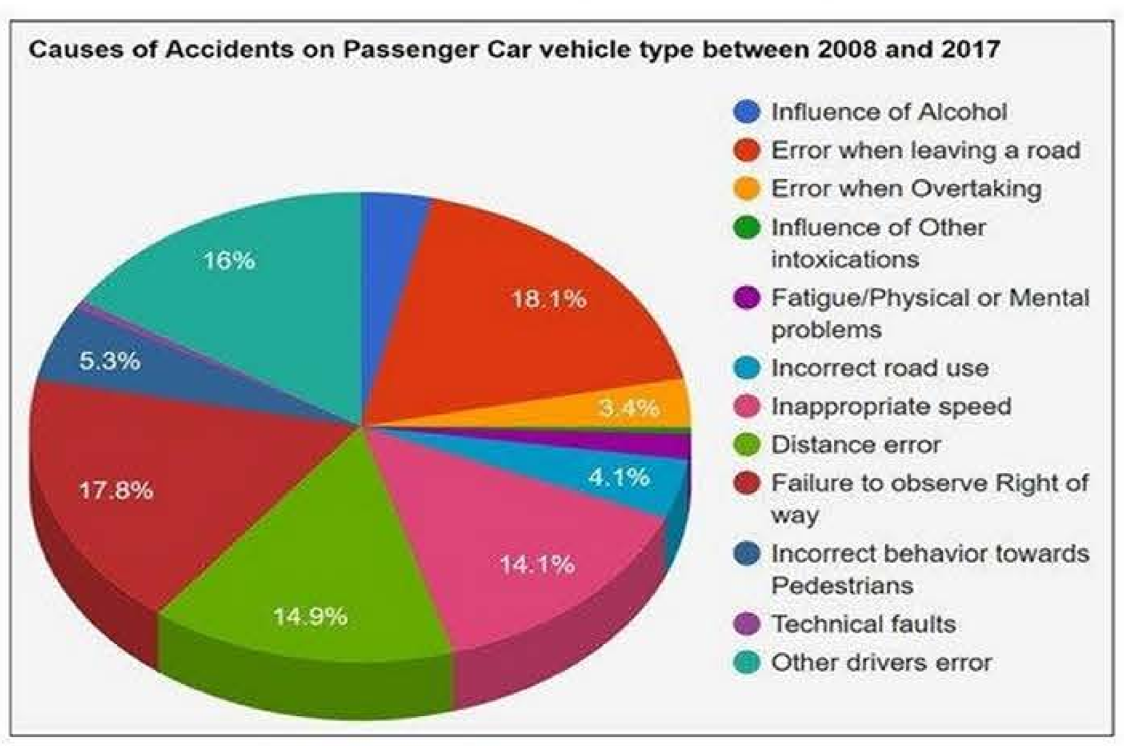
Continual increase of vehicles on road networks, alongside the human factor, necessitated the integration of the Internet of Things (IoT) driven by reliable communication technology incorporated within Intelligent Transport Systems (ITS) to conform within the autonomous vehicle arena.

This research aims to explore the realm of IoT and how it is integrated into self-regulated vehicles and other applications from a pragmatic standpoint. Application of contemporary data network facilities are demonstrated with detection and communication techniques such as machine learning to develop an effective IoT solution. An IoT model was constructed encompassing vehicular network technologies, based on empirical simulation to explain and substantiate the operation of system.

Background

Any network of objects such as vehicles, combined with electronic devices such as sensors and software connected via a communication system, are encompassed within IoT (Ashton, 2009), allowing a more direct integration of the physical world with information systems, thereby reducing human interference with ensuing efficiency, accuracy and economic viability.

Figure 1: Causes of accidents between 2008 and 2017 (Source: Khaliq et al., 2019)



Vehicle ad-hoc systems (VANETS), through Artificial Intelligence, have improved efficiency of cross-vehicular communication and can thus perform best-route calculations on the fly based on real-time events that transpire while in transit to a destination.

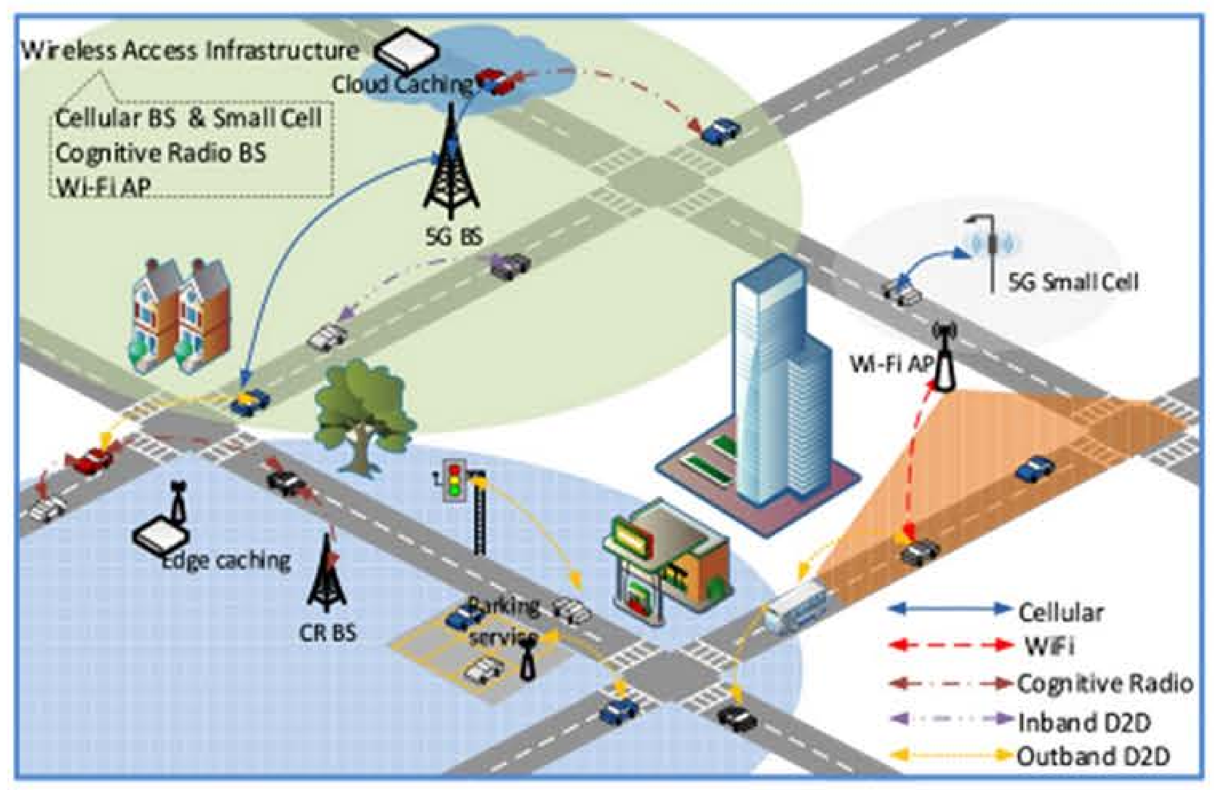
Routing

Reviewing V2V communication using VANETs, Abbasi and Kahn (2018) considered position-based protocols as opposed to topology-based protocols in urban settings, due to frequency of environmental topology changes. Insight is drawn to routing in forwarding techniques, means of junction selection, and methods of dealing with local peak traffic situations. Simulation of dynamic junction selection and static junction selection-based routing protocols was demonstrated. Researchers verified that for effective routing protocol, certain characteristics of VANETs resulted in unreliable communication. They claimed that high mobility and intermittent connectivity affected linkage and subsequent loss of packets within a network that fluctuates from congested to sparse. Researchers also felt that these attributes made security challenging, and established that the existing urban real-life environment is not suitably reflected in present routing VANET protocols and position-based protocols.

Zhang *et al*. (2016) propounded a congestion-aware routing algorithm to route a fleet of autonomous vehicles in a coordinated manner that does not increase congestion. Simulation demonstrated that routing and rebalancing (empty vehicle trips between drop-off and next collection) of self-regulated vehicles in a coordinated manner in Manhattan that provided mobility-on- demand service to customers could reduce pollution, demand for parking, and cost of travel.

Once a customer is serviced, the vehicle drives itself to the next customer and the network ensures that the proportion entering each node is equivalent to the proportion exiting node. Rebalancing therefore did not increase the total number of self-regulated vehicles on the road, as they were intelligently routed to avoid increasing congestion by optimising routes of both passenger-carrying and empty vehicles.

Figure 2: Wireless access infrastructure (Source: Cheng & Shen, 2016)



Other researchers also postulated that in managing a fleet of self-regulated vehicles, the mobility-on-demand system could help reduce capacity if multiple rides are serviced with a single trip. A New York study by Santi *et al.* (2014) showed that a taxi trip shared by two riders in Manhattan increased travel time in 80% of cases by only a few minutes, which was later verified by Alonso-Mora *et al.* (2017).

Method

By employing IoT vehicular technology, a computer model was designed and built representing the real-life environment to demonstrate through algorithms how the concept would function. Simulation models can be used to verify theory (Olivier, 2011). While computer security was addressed in line with Construct Theory and theoretical predictions, a simulation was performed and the results were analysed. As a requirement in computer simulations (Gulyàs & Kampis, 2015), replication testing was performed using different data input.

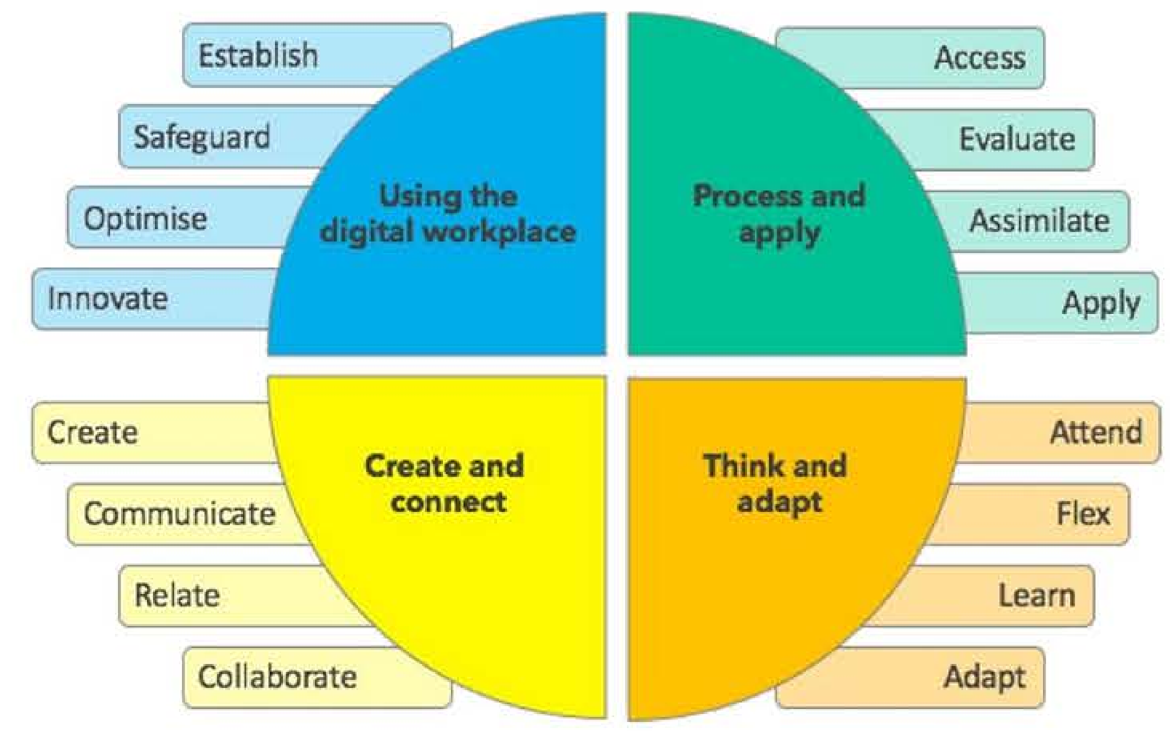
Digitalisation

"Digitalisation can inter alia be defined as the adoption of digital technologies to modify a business model. The aim is to create a value from the use of new, advanced technologies by exploiting digital network dynamics and the giant digital flow of information" (IGI Global, 2020).

Digitalisation beyond the discipline of the Internet of Things primarily refers to human-generated (digital) information and centralised autonomous systems. It creates digitisation of the physical world through dynamic and disseminated computation and algorithms into devices which humans are becoming more naturally dependant on.

Concerns are raised about Artificial Intelligence and human activity, cybersecurity and privacy, justifying an appetite for new skills and development. Digitalisation is knowledge gain; it encompasses understanding and application. As a foundation for *Design Thinking,* digital literacy holds responsible those who benefit from using the technology (Knitl & Erdebil, 2019).

Figure 3: Workplace Digitalisation (Source: Marsh, 2018)



Results

The experiment conducted in this research conformed to expected behaviour with similar outcomes in the analysis of repeat tests, thereby verifying initial results. This equated to the consolidation of the virtual world and the real world through computation and theoretical reasoning (Sastry, 1997).

Future Research

Further research is needed in the following areas:

- VANET routing performance, as environmental characteristics are not accurately reflected (Abbasi & Khan, 2018)
- Security research in multi-faceted IoT automotive computer systems with possible in-built repair systems
- VANET communication in an infrastructure-less environment to prepare assimilation of vehicular networks with 5G mobile technology

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