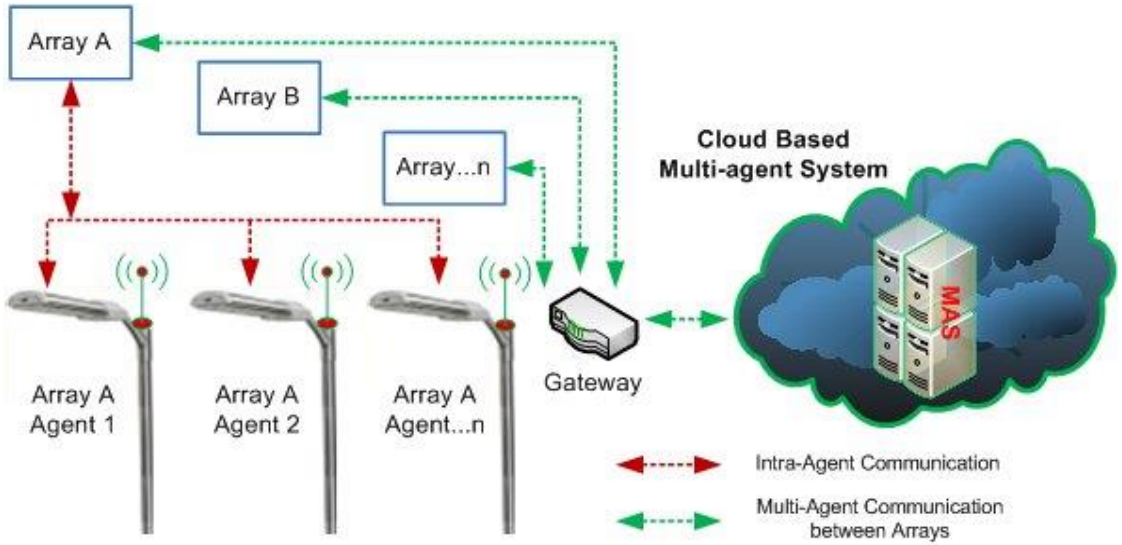
RĪGAS TEHNISKĀ UNIVERSITĀTE
Industriālās elektronikas un elektrotehnikas institūts

INTRODUCTION TO CLOUD BASED MAS CONTROL FOR RADAR TYPE AND LONG RANGE HYBRID PIR SENSORS IN SMART LED STREET LIGHTING SYSTEM



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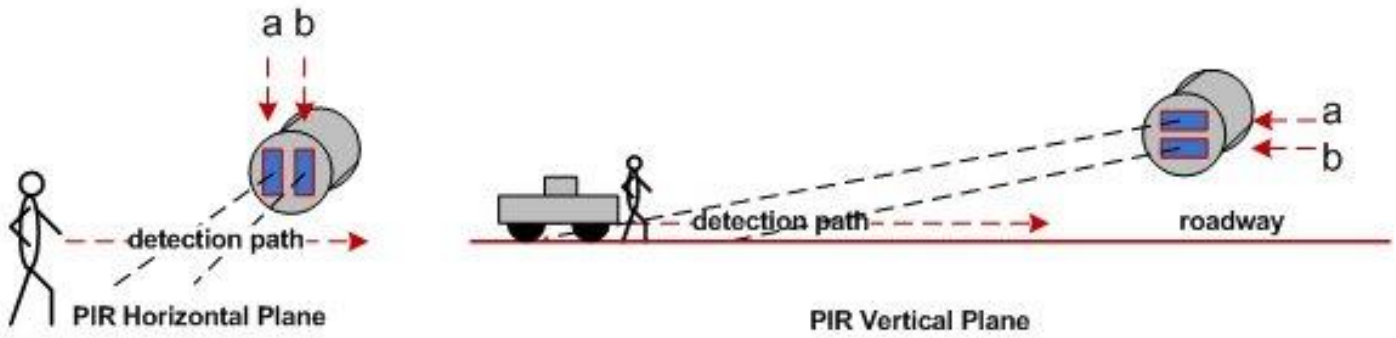
I. The paper is propositional in its description of the adaption of a hybrid infrared detection system for smart street lighting applications and inclusion within an MAS.

II. The primary sensor utilizes a single modified Piro-electric Sensor, a radar type sensor, a static infrared array and a purpose designed long range IR lens system. The original design was to provide a priori warning system for approaching vehicles or pedestrians.

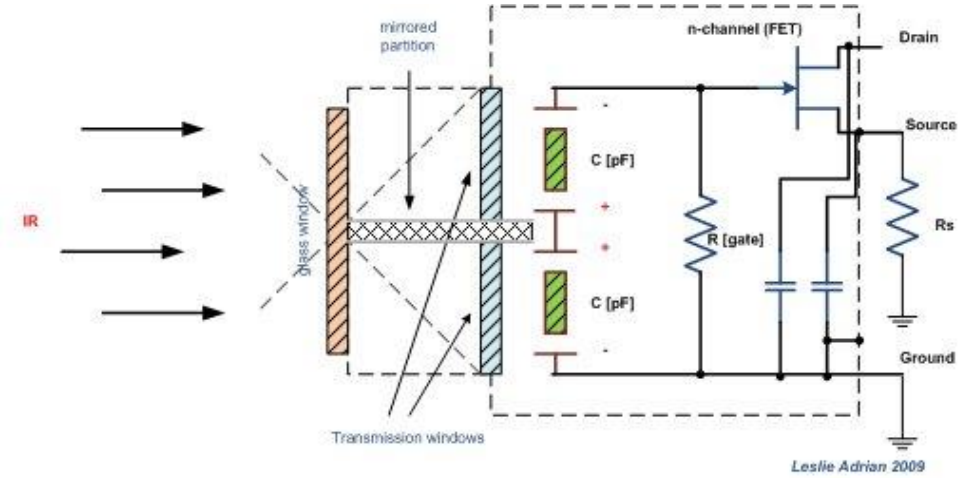
III. The sensor incorporates both static and non-static infrared detection systems with long range directional and velocity detection capabilities.

IV. Automatic lighting control, dimming and brightening was the initial purpose of the design and includes by default the tracking of vehicle and human subjects. Of late the system incorporates many sensor features, making it an ideal candidate for "***big data***" collection.

V. The initial prototype was designed to be attached to the lighting pole system at an appropriate angle to enable sensing to a distance of 100 meters.



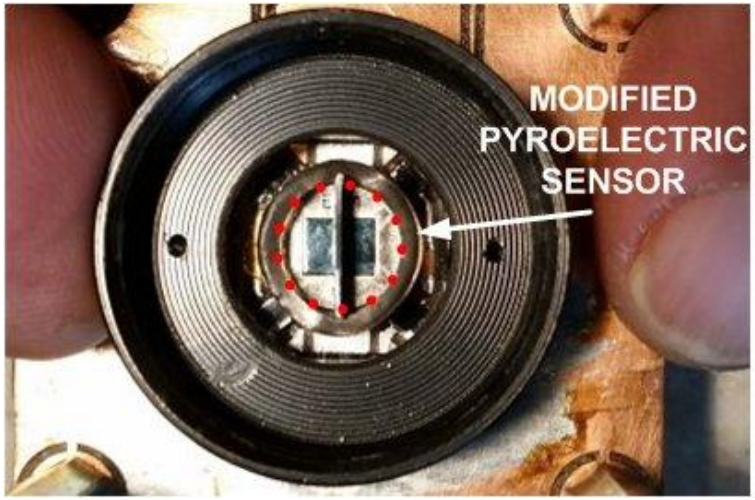
System Basics



Schematic of Modified Pyroelectric Sensor

Modified Pyroelectric Sensor housed in prototype.

Purpose: Detection of bi-directional IR motion



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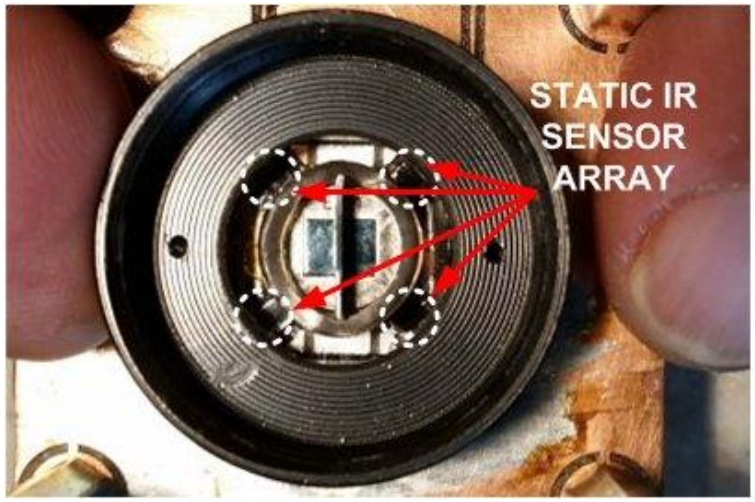
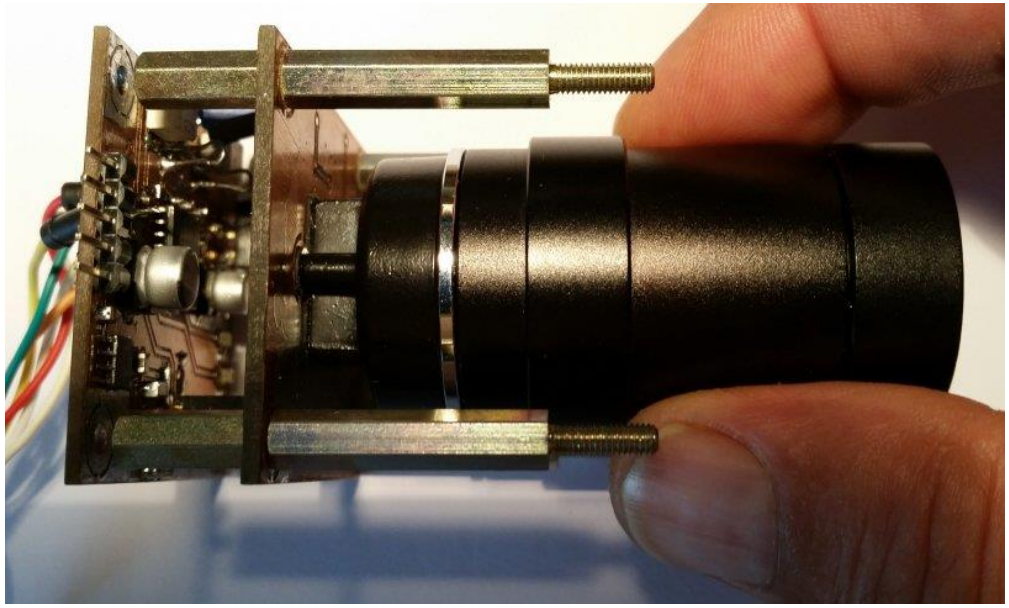


Static IR Sensor Array housed in prototype.

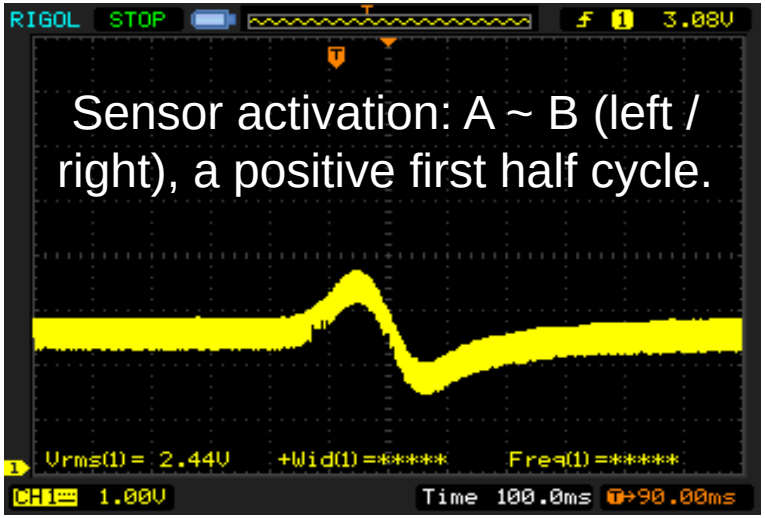
Purpose: Error detection. Detection of stationary or intermittent IR heat sources.

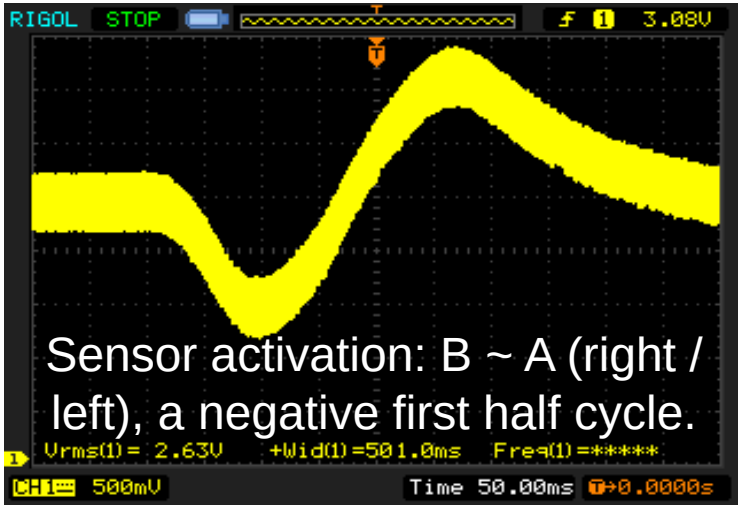
System Basics

Original Prototype showing circuitry and Lens.



Direction and Velocity Methodology





Direction indication is seen by either a positive or negative response on the wavelength first half cycle.

Velocity estimates are based on measurement of the peak to peak of the full cycle.

Algorithm Methodology

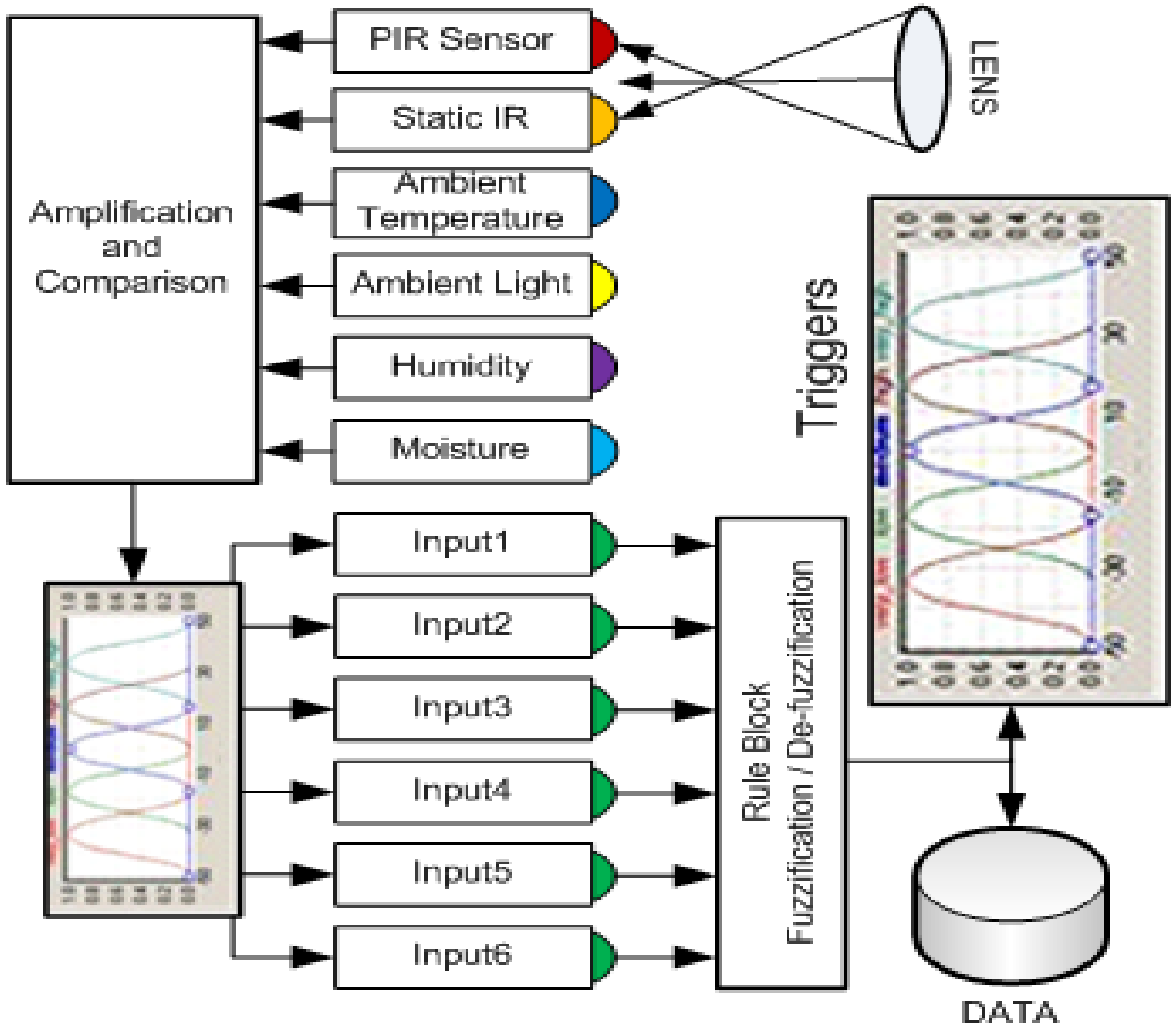
A Fuzzy Logic algorithm has been used as a matter of author preference. The table represents an extract from the “Rule Block” for the purpose of simplification of the approach to lighting control.

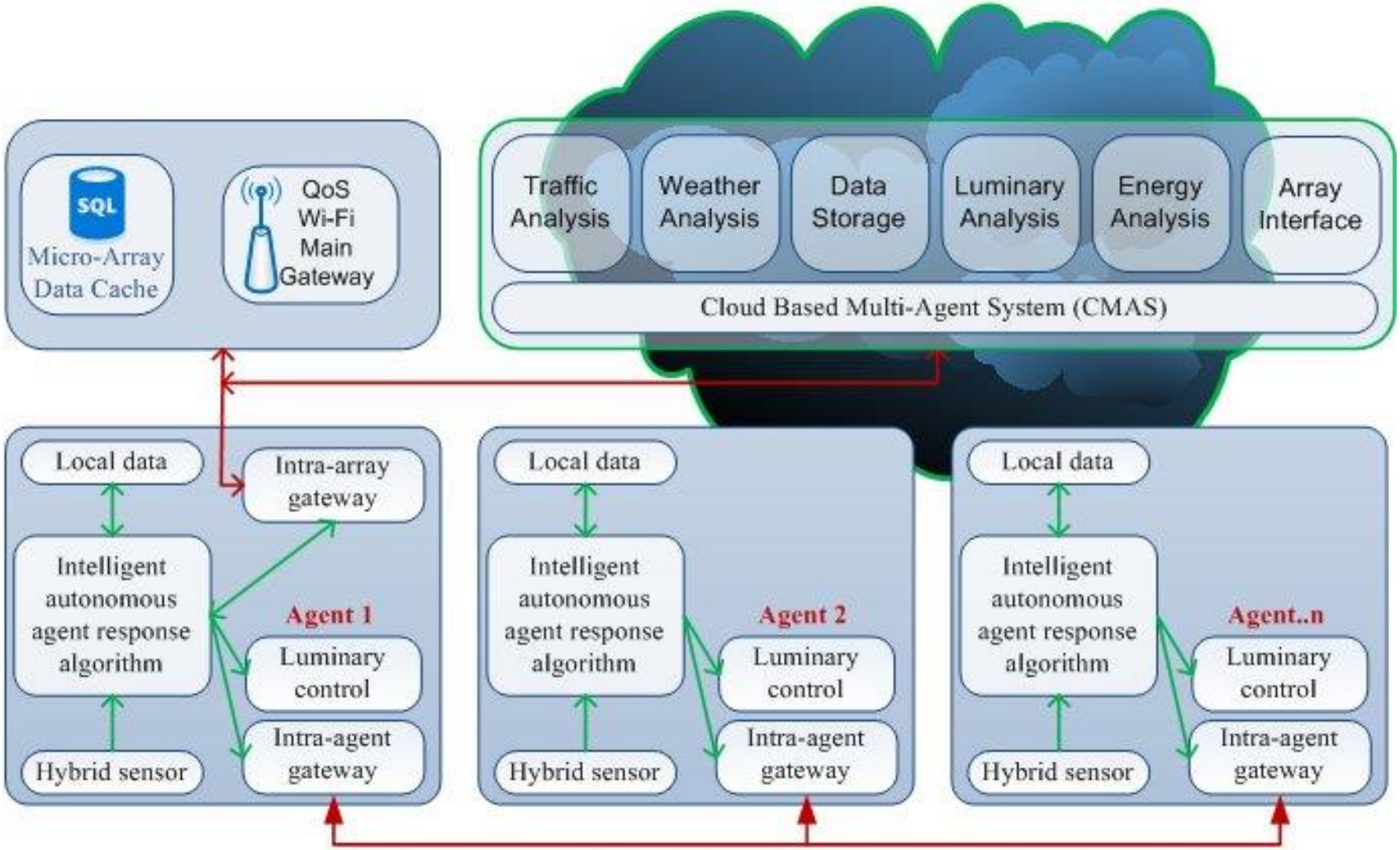
if	*And*	*And*	*And*	*operand*	*then*
PIR_AB.high	PIR_BA.low	mV_Pos.med	IR_Static.high	=>	Trigger_high
PIR_AB.low	PIR_BA.low	mV_Pos.low	IR_Static.high	=>	Trigger_low
PIR_AB.low	PIR_BA.high	mV_Pos.high	IR_Static.med	=>	Trigger_low

Simplification of line 1:

If “Vehicle is Approaching” ***and*** “Vehicle is not Departing” ***and*** “PIR Sensor Signal is Strong” ***and*** “Static IR Sensors are Strong” => ***then*** “Brighten The Street Lighting”.

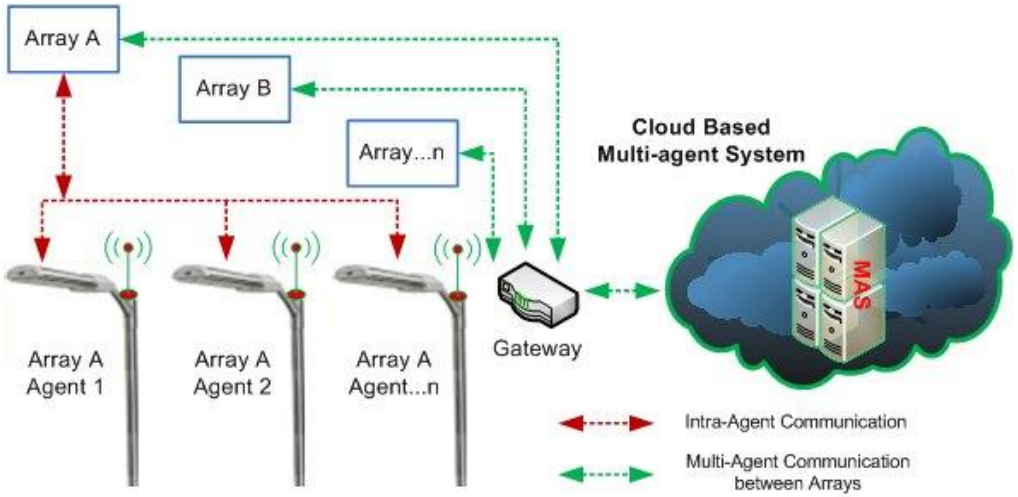
Expanded capabilities of the sensor and the CMAS approach to Data retrieval and analysis.




SQL
Micro-Array Data Cache
QoS Wi-Fi Main Gateway
Traffic Analysis
Weather Analysis
Data Storage
Luminary Analysis
Energy Analysis
Array Interface
Cloud Based Multi-Agent System (CMAS)
Local data
Intra-array gateway
Intelligent autonomous agent response algorithm
Agent 1
Luminary control
Intra-agent gateway
Hybrid sensor
Local data
Intelligent autonomous agent response algorithm
Agent 2
Luminary control
Intra-agent gateway
Hybrid sensor
Local data
Intelligent autonomous agent response algorithm
Agent..n
Luminary control
Intra-agent gateway
Hybrid sensor

MAS Development Factors

The micro-array (Array A to Array…n) may be defined as a road, street, walkway or any other area designated for installation of the system and having defined as its (agents or actors) the intelligent streetlights complete with their sensory systems.



An agent (Agent_1 to Agent_n) may be interconnected or islanded from the network and therefore is composed of two distinct states. The agent is ascribed asynchronous communication, such that the sending and receiving of message and control data is independent of a coordinated clock signal between agents due to the requirement for each to operate within a unique and dynamic environment.

Hybrid Sensor (operating under fuzzy logic architecture)

- Long and close range vehicle and human detection
- Movement direction (L/R or R/L) detection including detection of approaching or departing vehicles
- Vehicle counting and in a lesser degree pedestrian counting
- Approximated vehicle velocity and vehicle headlight recognition
- Ambient temperature sensing, ambient light sensing and wet weather detection
- Compatibility with most existing lighting systems

LED Street Lighting System (using hybrid sensors)

- Increased energy efficiency – light delivered only when and where needed (less light pollution)
- Exact lighting class determination on real traffic data according to EN13201
- New services and functionality added to the system (improved Return of Investment values)
- Introduction of new Prediction, Maintenance and Control algorithms
- Decentralized control, system can analyze and make decisions – system becomes smart
- Context data application to enable participation in energy price markets (like Nordpool) or adjust consumption according to current price forecast

Non-Synchronous System

- A synchronization strategy holds little importance due to the dynamic nature of the *Agents.*

- Operation as a distributed system normally requires that all *Agents* operate in a synchronous manner and the various *Agents* and the synchronization within the system is a primary and necessary objective.

- Without this synchronization, complex software modeling and simulations applications fail to function.

- As an example, in a pedestrian counting simulation, the physical area where targeted pedestrians are located may be segregated into various parts and may be monitored by an *Agent*. However those pedestrians may wander from one physical location to another and without a mechanism for synchronization, pedestrians walking from one *Agent* to the next would be misplaced in real-time where one *Agent* is ahead or behind in the model simulation. Therefore uncontrolled synchronization would generally invalidate the simulation process due to overlapping of past, present and future tense events or triggers. It should be apparent that even an non-synchronous system dealing specifically with random data collection may be synchronous after an event, when collated in date/time format.

Non-Synchronous System

- Therefore, the main goal is to achieve data transfer to the CMAS which is the primary decision maker at the heart of the operation.

- The problems associated with synchronization is one of system overhead, requiring ever more complex data retrieval and processing algorithms.

- Within the proposed system there is a view to total removal of synchronization overhead which does not trade accuracy or performance.

- The multi-layered architecture of the system proposes increased accuracy over time, providing more accurate energy, traffic, pedestrian, weather and area-specific trends.
- most expectations have been met with respect to the use of the Long Range Static and Non-Static Hybrid Infrared Detection System for lighting control purposes.
- the device is currently funded and must be adapted to an existing street lighting system to fully understand evalute its effectiveness and potential.
- There has been some uncertainty in the Lens development area with a wide range of sensitivities being recorded. This is due in the main to reliance on the use of stock lenses which are inexpensive and not task specific.
- Continuing stages of the project involve further development of suitable optics and will require considerable funding in order to achieve.
- Development of parallel controller: Refer: *"Introduction to parallel MAS control for MAS - smart sensor networks" (RTUCON-2019)*
- The system appears stable and robust and certainly worthy of further investigation as an intelligent power management Device (iPM).

Thank you for your attention!

Acknowledgment

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