RM-IoT: An IoT-based Rapid Medical Response Plan for Smart Cities

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Outline of the talk

- Introduction
- Novel Contributions
- System level Modeling of Smart Medical Response Plan
- Implementation and Validation
- Conclusion and Future Research

Introduction

- Response Plan
- Significance in Smart Cities
- Internet of Things

Introduction

✓Response Plan

- Response Plan helps in analysing the possibilities of overcoming disasters and emergency scenarios such as oil spills, epidemic breakouts, cyclones and so on.
- It helps in reducing damages caused and effectively rebuilding the city by assisting its citizens.

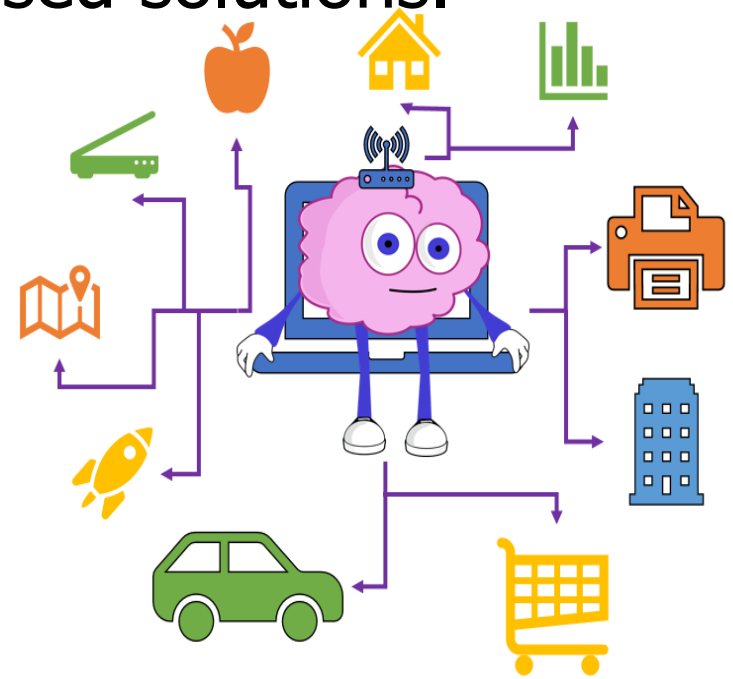
Introduction

✓ Significance of Response Plan in Smart Cities

- Due to the increasing urban population, the response plan needs to be automated in order to efficiently serve every citizen.
- Having a **secure and connected framework** to continuously monitor the consumers can help in treating them once there is an on-set of particular medical condition.

Internet of Things (IoT)

- The Internet of Things helps in connecting real world sensor data to cloud based solutions.
- The IoT acts as a virtual brain of wireless sensor networks which can be realized as mixed signal systems.



Conceptual Overview of the proposed RM-IoT framework

Novel Contributions

- An IoT-based rapid response plan, RM-IoT, which helps in improving the overall health and living conditions of people in a community, is proposed.
- Priority-based data classification is done based on the severity of the parameters related to the specific condition being monitored.
- In the proposed system, along with addressing the critical scenarios, a solution to address high priority alerts is also given.

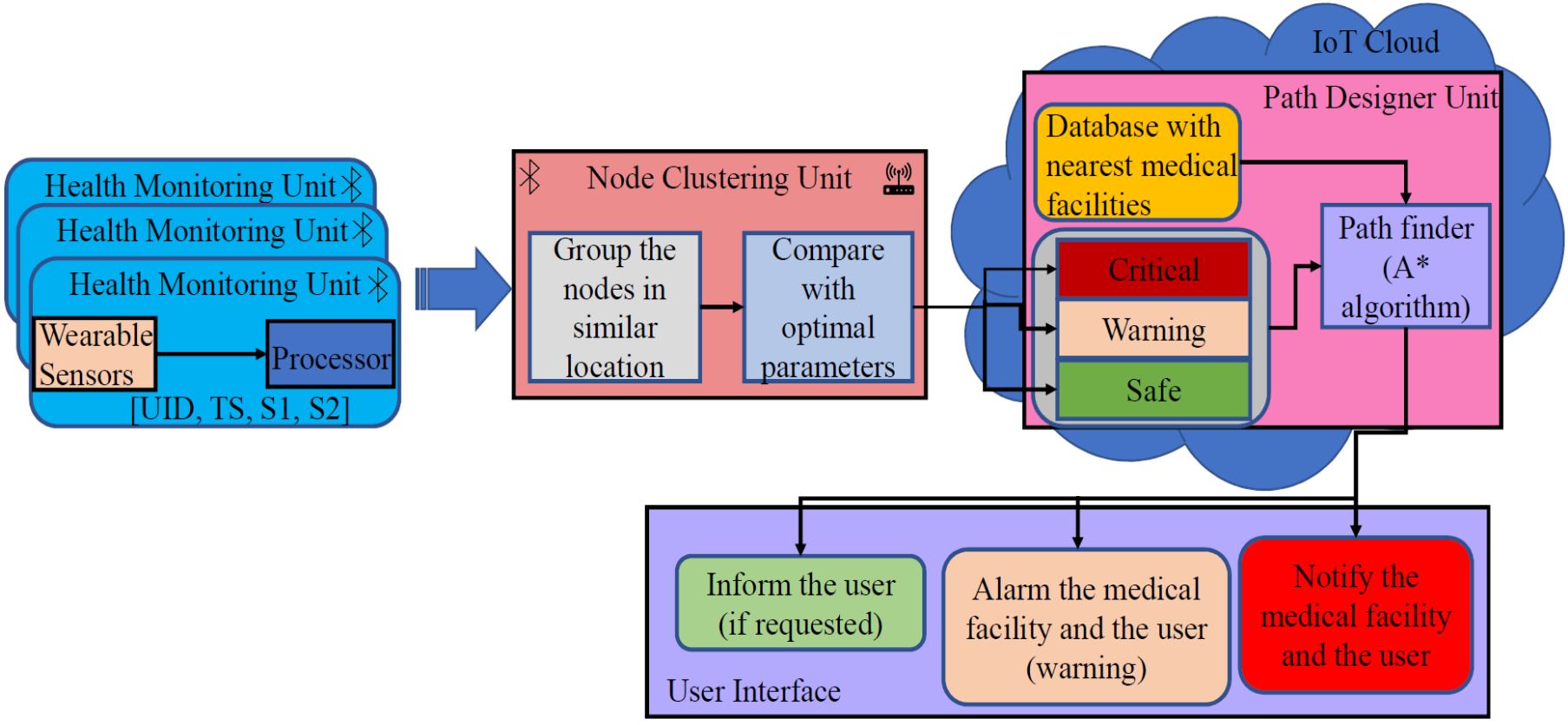
Novel Contributions

- A response plan based on the A* (A Star) search algorithm to find the nearest hospital in case of any emergencies is modeled.
- The clustering of data based on their priority is shown in CupCarbon.
- The proposed framework is modeled in CupCarbon using Senscript and the performance is analyzed in terms of energy efficiency and battery life.

System Level Modeling of Smart Medical Response Plan

- Health Monitoring Unit in Smart Cities
- Algorithm for Smart Response Plan

Overview of IoT-based Smart Medical Response Plan



System level Modelling of Smart Medical Response Plan

✓ Health Monitoring Unit

- The severity of the response plan can be decided based on the physiological parameter being monitored. Here the parameters considered are temperature and heart rate values.
- Correlating the temperature sensor values along with the heart rate values can help in monitoring underlying conditions and address critical conditions immediately.

System level Modelling of Smart Medical Response Plan

✓ Node Clustering Unit

- Measuring patient temperature and heart rate data, and assigning the data to an individual node for countless patients can be better facilitated through basic node clustering.
- In the NCU, nodes of similar locations are grouped together which helps in the computation of the shortest path from the source to the destination easier.

System level Modelling of Smart Medical Response Plan

✓ Path Designer Unit

- After grouping the nodes, the optimal parameters are compared to classify the data into critical, warning and safe.
- The output of the node clustering unit is sent to the Path Designer Unit (PDU), implemented in the IoT cloud, where the grouped data is given as input to the pathfinder along with the database of the nearest medical facilities.

System level Modelling of Smart Medical Response Plan

✓ Algorithm for Shortest Path

- The use of nodes is undoubtedly useful for quick data transfer, and an algorithm can be applied to determine the fastest, or most optimized, path from the source (in this case the patient's place of residence) to the destination (the medical facility) in an intricate network of nodes found in a smart city.

System level Modelling of Smart Medical Response Plan

✓ A* Algorithm

- A highly successful pathfinding algorithm for finding the shortest distance between nodes.

- This algorithm is a best-first search algorithm and is an extension of Dijkstra's algorithm.

System level Modelling of Smart Medical Response Plan

✓ A* Algorithm

- The A* algorithm considers three main values during execution: total weight f(n), cost of the path from the start node to n (g(n)), and the heuristic value, or the cheapest path to the destination (h(n)).
- The heuristic distance, for the purposes of the algorithm implementation, can be thought of as the Euclidean distance between n on the plane to the destination on the same plane.

System level Modelling of Smart Medical Response Plan

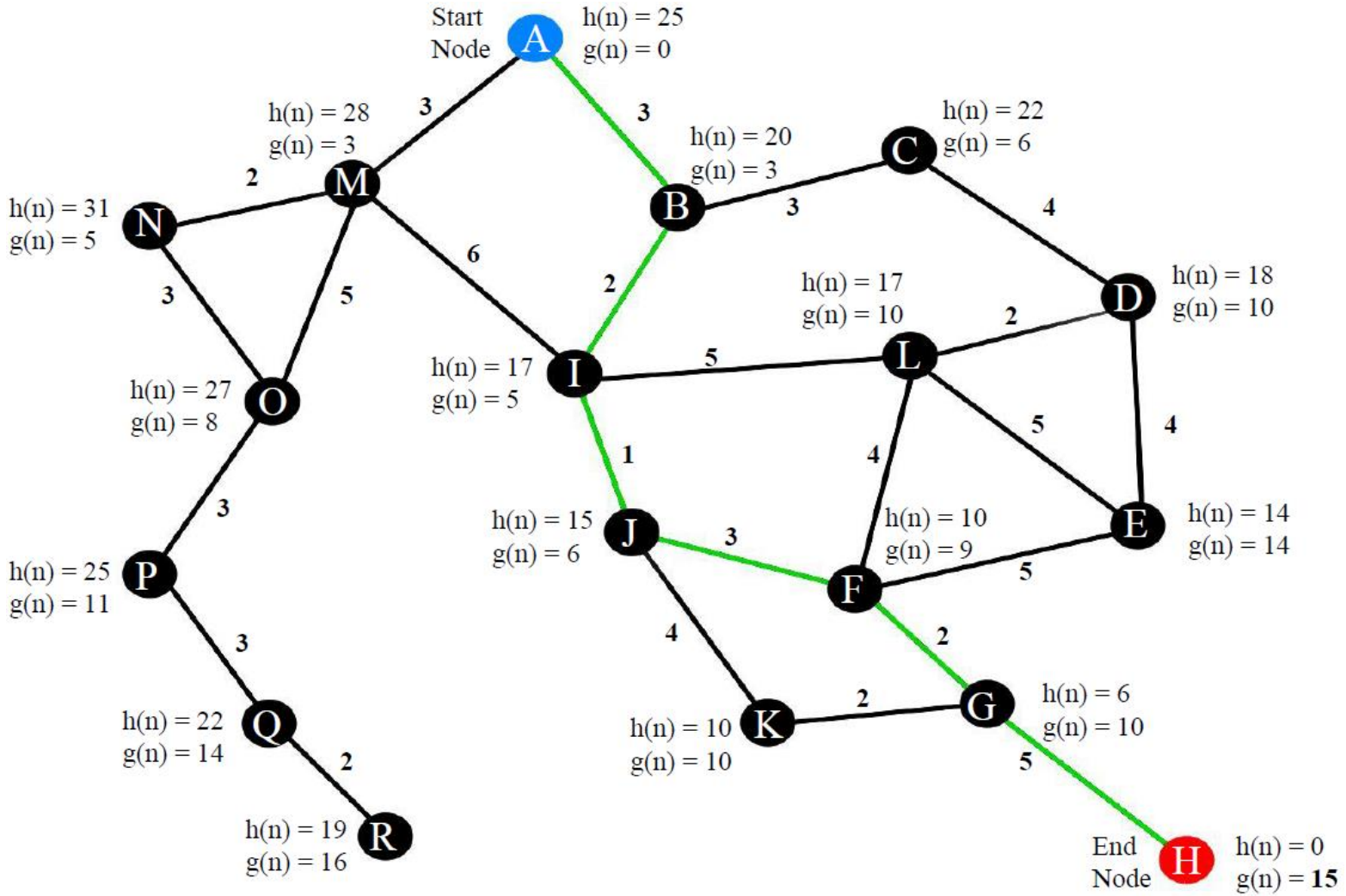
✓ A* Algorithm

- The total weight value f(n) is sum of g(n) and h(n) as given in the following equation:

$$f(n) = g(n) + h(n)$$

- The total weight obtained at each node is the deciding factor for optimization. When the algorithm is implemented to compute the shortest path from source to destination, the nodes are divided into three groups: open (fringe), closed, and uninitialized (unevaluated).

Illustration of A* Algorithm



List of Closed, Open and Unevaluated nodes for the Illustration Graph

Closed List Nodes	Fringe (Open) List Nodes	Unevaluated Nodes
A (Start Node)	M	D
B	C	N
I	L	O
J	K	P
F	E	Q
G		R
H (Destination)		

Implementation & Validation of Smart Medical Response Plan

- Custom-Built Health Monitoring Unit
- Evaluation of Implementation Platforms
- Prototype of Smart Medical Response Plan

Implementation of Smart Medical Response Plan

✓ Custom-Built Health Monitoring Unit

- The Health Monitoring Unit and Node Clustering Unit were designed with the help of commercially off-the-shelf components.
- The health monitoring unit was designed using an MCP9808 temperature sensor, and MAX30102 Pulse Oximeter as a wearable.

Implementation of Smart Medical Response Plan

✓ Custom-Built Health Monitoring Unit

- The Node Clustering Unit was implemented using a single-board computer, the Raspberry Pi 3+.

- The data collected from the wearable through the single board computer is later processed using the IoT cloud.

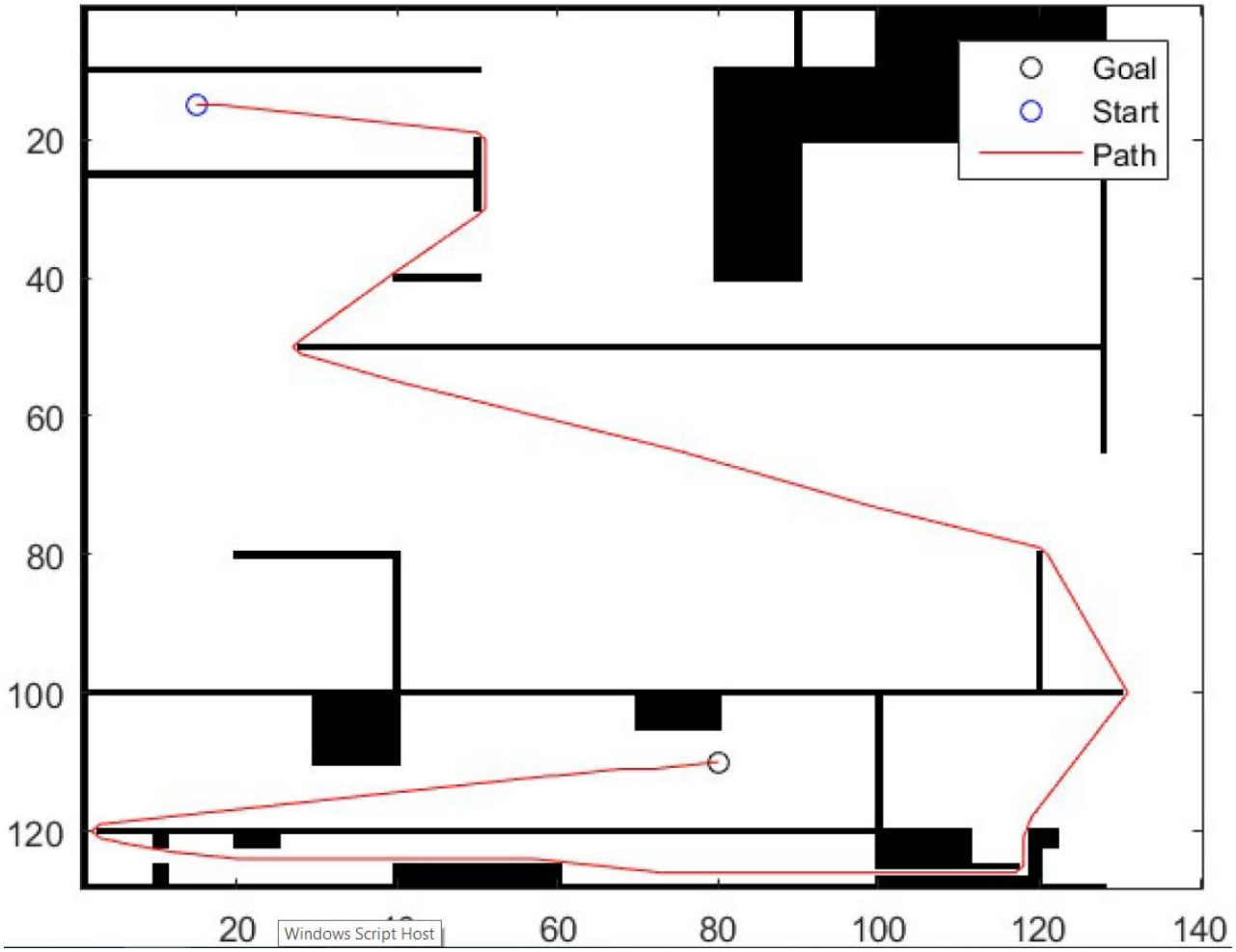
Evaluation of Implementation Platforms

✓ A* Algorithm in MATLAB®

- Response plan modeling using the A* algorithm in MATLAB® is unfortunately not suitable for the tasks at hand as MATLAB® evaluates entire matrices.

- The A* algorithm and other single source graph search algorithms can be best used for navigating through obstacles to reach the destination.

A* Algorithm in MATLAB®

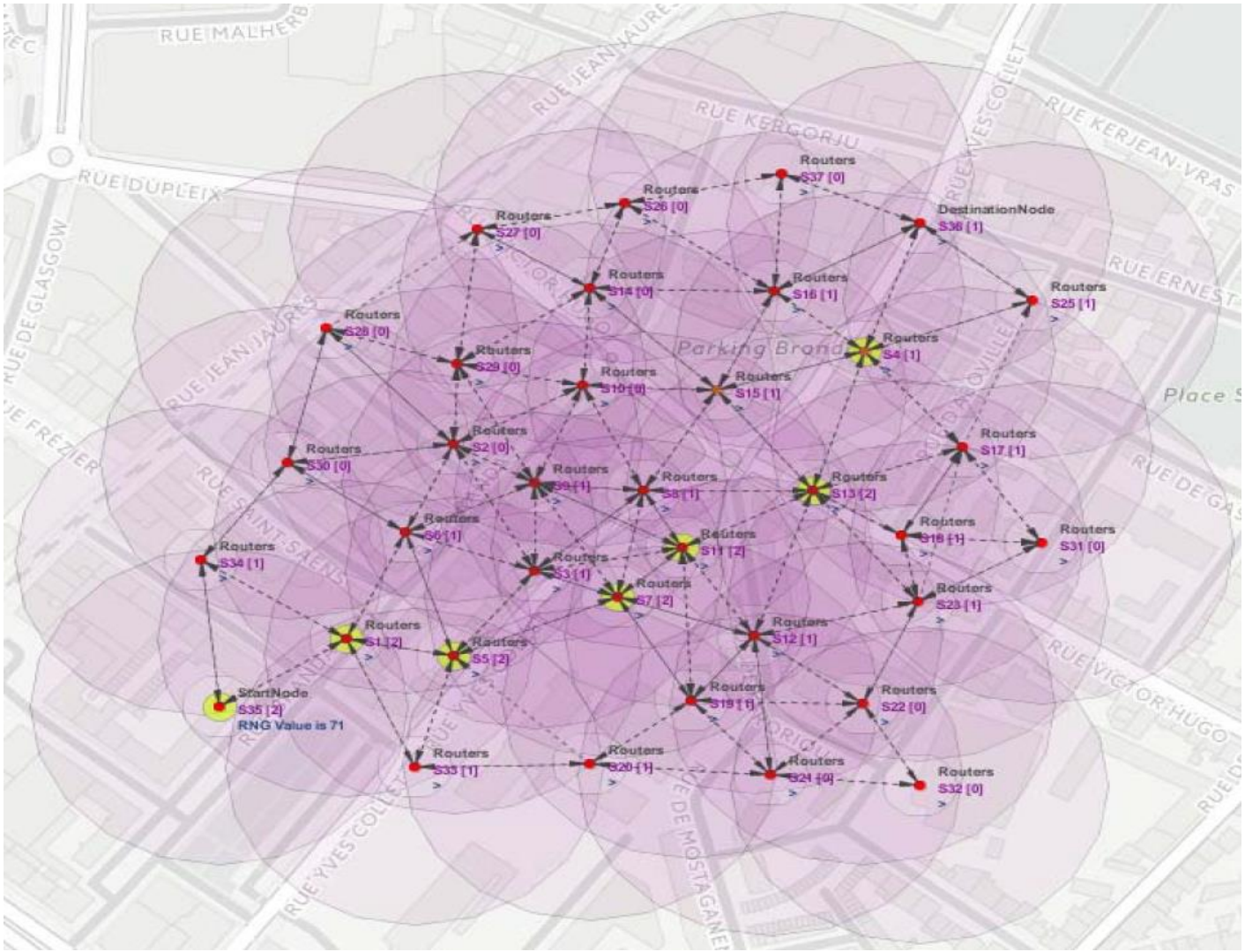


Evaluation of Implementation Platforms

✓ A* Algorithm in CupCarbon

- CupCarbon has built-in functionalities, such as the ability to deploy multiple nodes and the ability to analyze energy efficiency, battery levels, power consumption, and other simulation parameters, hence the overall efficiency of the system is analyzed.
- The Algorithm in CupCarbon is focused on finding the shortest, cheapest path through connected nodes, with movement limited to the defined paths between adjacent nodes.

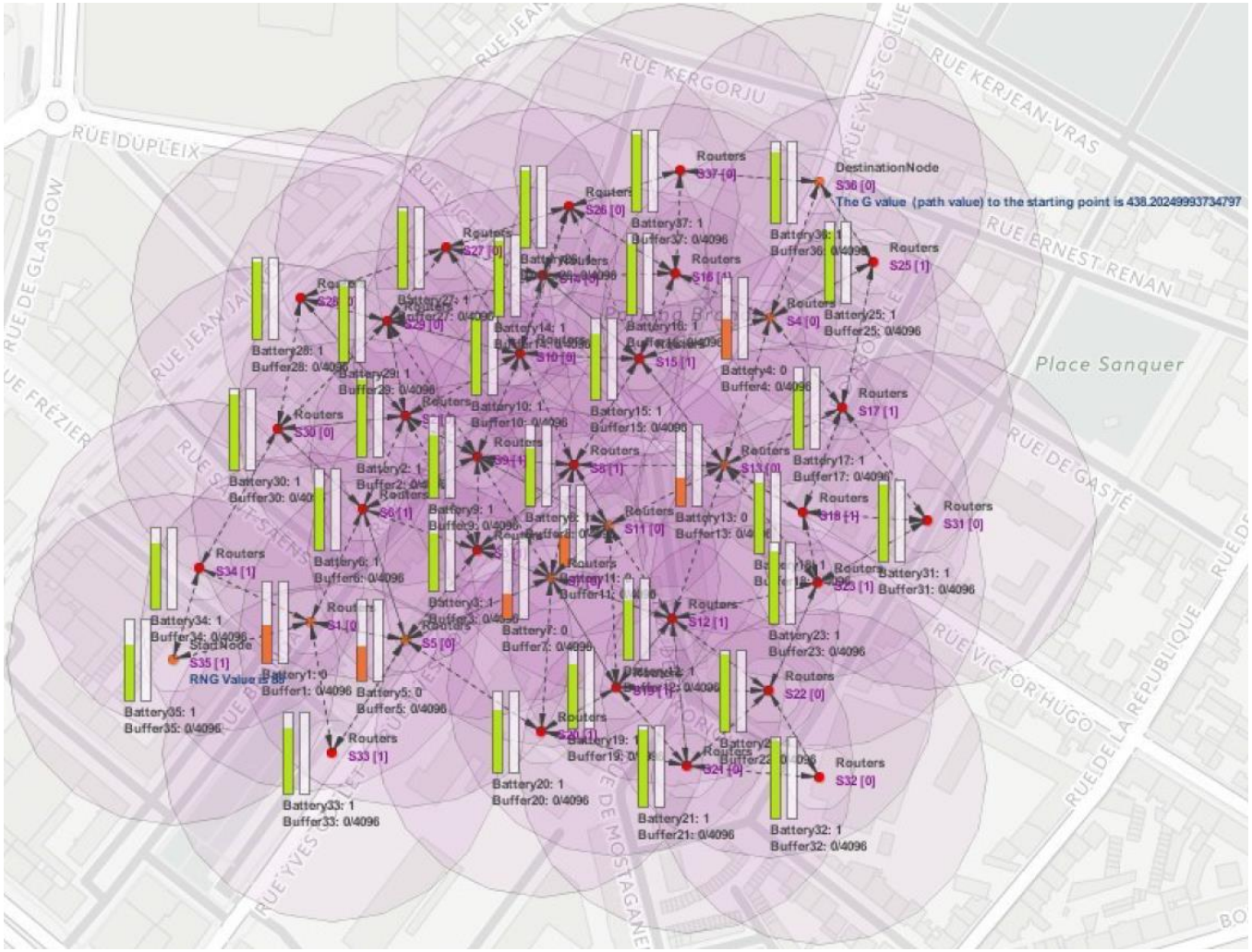
A* Algorithm in CupCarbon



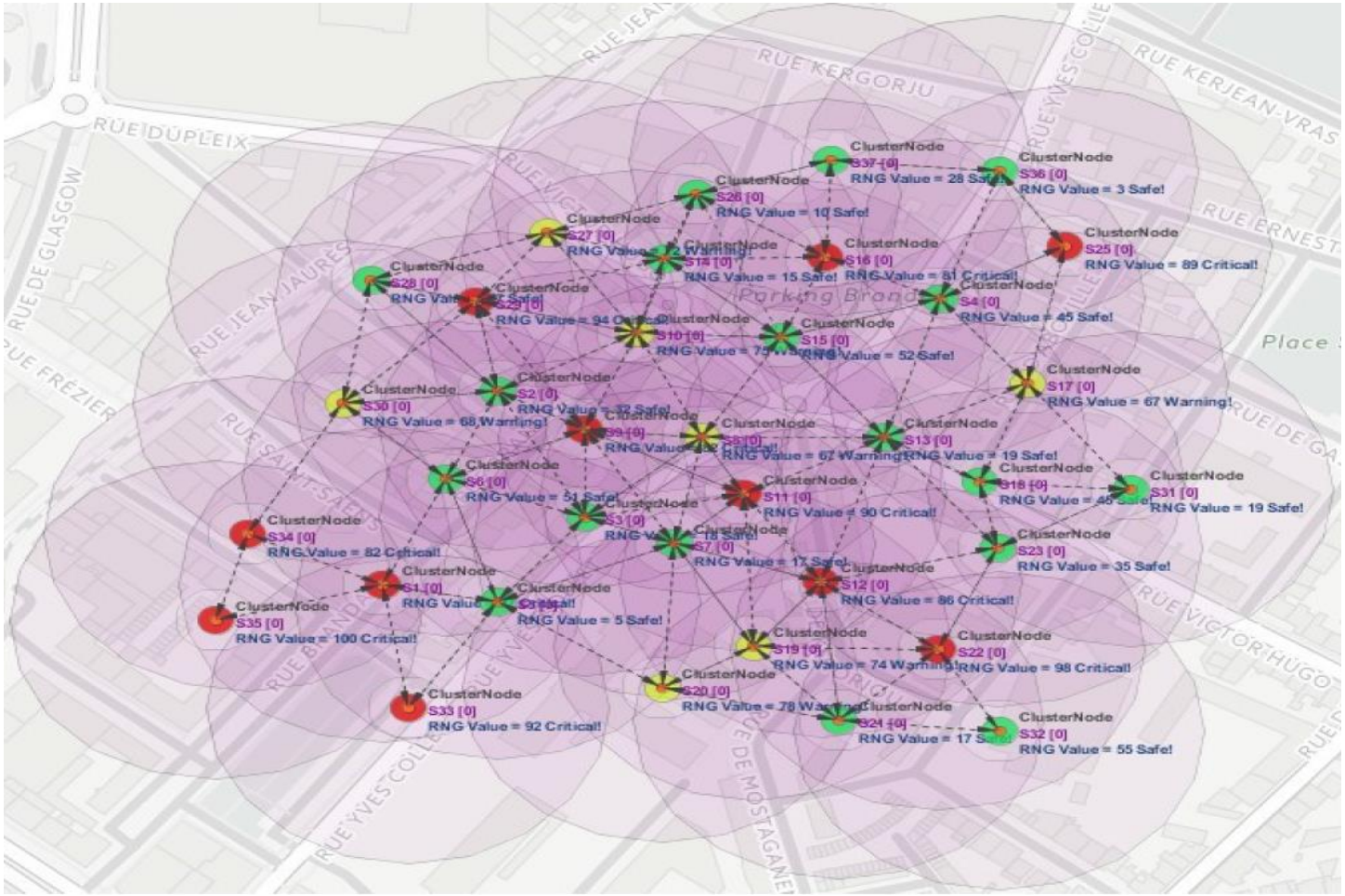
List of Closed List, Open List, and Unevaluated Nodes

Closed list nodes (MY=2)	Fringe (Open) list nodes (MY = 1)	Unevaluated nodes (MY=0)
S35 (Start node)	S34	S28
S1	S33	S29
S5	S6	S30
S7	S9	S2
S11	S3	S27
S13	S20	S26
S4	S19	S10
S36 (Destination)	S8, S12, S23, S18, S15, S17, S16, S25	S14, S37, S21, S32, S22, S31

Battery Analysis of Each Node in CupCarbon



Visualization of Node Clustering in CupCarbon



Smart Electronic System Laboratory (SESL)

Evaluation of Smart Medical Response Plan in CupCarbon

Characteristics	Methods/standards/values
Response plan algorithm	A* search algorithm
Number of devices	40
Radio Standard	ZigBee(802.15.4)
Simulation Time	95 seconds
Number of SENT messages	124
Number of RECEIVED messages	230
Number of ACK messages	17
Number of LOST messages	0
Computational Platform Specifications	
Processor	Intel Core i5-7200 CPU running at 2.50 GHz
Operating System	Windows 10

Conclusion and Future Research

✓ Limitations of CupCarbon

- The global variable and data storage is not very efficient in CupCarbon.

- The intercommunication between the nodes is based only on sending and receiving messages between adjacent nodes.

Conclusion and Future Research

- This paper proposes a framework for smart medical response plan.
- The CupCarbon implementation helps in visualizing and analyzing the real-time limitations and emergency scenarios.
- Community-based remote assistance helps in improving the quality of life and reduces the amount of money spent in the individual generic wearables.

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Thank You !!!