Routing decentralized light bodies

Internet of Things

Technische Universiteit Eindhoven University of Technology

ID VisionLab

Routing Decentralized Light Bodies

Logical mapping and user interfaces for decentralised control of distributed lighting nodes

Introduction

In the context of an increasingly connected world, Internet of Things solutions in industry and literature are typically designed and implemented in a centralised fashion: there is either a single controller coupled tightly with sensors and actuators of devices or data is centrally aggregated in the cloud, where the value is ultimately created. The aim of our work is to design and prototype a lighting application, that exhibits specific light behaviour through fully decentralised control.

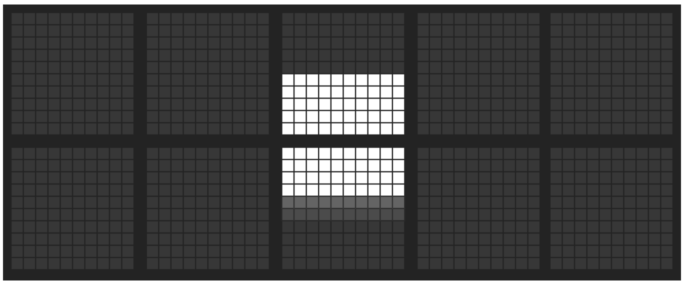

Fig 1. System-level simulator of light behaviour (web-based; interactive)

The lack of hierarchy between components of the system leads to unique qualities: (1) resilience, the system is inherently more fault tolerant than a centrally-controlled system, and (2) emergence, being able to develop new behaviours naturally with the addition of different components. We extend our work beyond purely technical control topics and strive for a “vertical” of generic embedded lighting modules that are directed or orchestrated by a high-level user interface. Such a solution enables quick integration of new functionality and even the emergence of new system behaviours.

Challenges

Decentralised control works differently than conventional central control: system behaviour results from node behaviour. Defining system behaviour at a high-level is relatively simple; translating this into a “cooperative effort” by individual nodes requires a non-trivial transformation of control and thus significantly different approach.
In addition, conflicting behaviours can arise as system behaviours expands. It is an open question how to compensate the lack of hierarchy at the device level and to ensure operation compliant to the desired system behaviour.

Approach

A proof of concept network was built on 25 Wifi-connected Raspberry PI 3 units, each coupled with an LED matrix display (cf. Fig 2). Wireless communication between devices enabled the composition of a large lattice on which the system’s lighting behaviour could emerge.

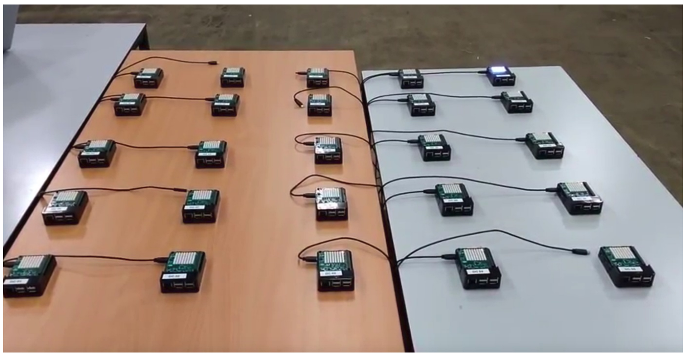

Fig 2. Prototype installation: lattice of 25 Wifi-connected light nodes (Raspberry PI)

Behaviours

Several lighting behaviours were then prototyped on this network, e.g., routing single points of light traveling between nodes, larger light bodies (i.e., multiple active points) moving between areas and smooth visual transitions. To allow for more flexibility in how the system could be orchestrated and more versatile behaviours, system instructions were modelled as “currency” transactions. That is, instead of switching light nodes, ”portions" of the light are exchanged between nodes.

Interfacing with users

At a high level, a decentralised approach requires translating a trigger from an individual node into a larger system behaviour. This leads to a high density of controls for individual nodes. To address this problem, we implemented a web-based simulator that allows to test and fine-tune system behaviour before deploying to the decentralised network.

Conclusions

We demonstrate that decentralising system input is possible and show a prototype that lets multiple lighting nodes contribute to a larger system orchestration – with fully decentralised control, emergence and extensibility.

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