DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Thesis type (Bachelor's Thesis in Informatics, Master's Thesis in Robotics, . . .)

Thesis title

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I confirm that this thesis type (bachelor's thesis in informatics, master's thesis in robotics, . . .) is my own work and I have documented all sources and material used.

Munich, Submission date Aly Saleh

Acknowledgments

Abstract

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1.1.1 Show how Iot is being currently used, its pros and cons

1.1.2 Give an idea about the devices used to make a distributed sensor network

1.2 Motivation

1.2.1 Show the need to explore Pervasive Computing

1.2.2 Illustrate why it might be better to distribute the data in some cases rather than accumulating it in a single server

1.2.3 Explain why Cloud Computing is not always the right solution in some cases

1.2.4 Explain the need to find IoT devices capabilities and limitations when used for data computation

2 Background & Related Work

2.1 Introduce Edge, Fog and Pervasive computing, how they are used in this context

2.2 Explain how sensor data data is modeled and distributed in the current published approaches

2.3 Illustrate what are the ideas and possible network mechanisms and protocols that could be used data transfer

2.3.1 Server To Server

2.3.2 Server To Device

2.3.3 Device To Device

2.4 Explain Opportunistic networks and SCAMPI architecture

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3 Approach

3.1 Requirements

3.2 Use Cases

3.3 Modeling of Input Sensor Data

3.3.1 Show how the different sensors have data been modeled to fit our requirements for further use in computations

3.3.2 Dealing with Resources

3.3.2.1 We cant make assumptions about resources

3.3.2.2 Resource capability description

What are the options that we have in order to describe, infer or discover our resources ex " Resource Configuration File", linux commands, service discovery , code .. etc.

3.3.2.3 Decoupling Resources

3.4 Pushing the Computation to the Edges "Nodes"

3.4.1 Execution Model

- Which nodes should execute the data, is it all, some or a specific nodes. Also, how is the model specified in the computation meta data. - How do we know if a Computational Instance has been executed or not.

Since the goal is to push computations to the available nodes which have the capability to do so, there are three main aspects that must be addressed to achieve this goal.

- First, is to be able to express the computational requirements and resources that the computation is going to use while running on a specific node, which is also

called **"Compuation Meta-data"**. Since we cannot make assumptions that a certain node has specific resources or specification as explained in 3.7.1.1, these requirements has to be pushed along with the computation. It includes, for instance, the amount of processing power and random access memory the computation is going to need, also, the resources required to perform such a computation. The meta-data is expressed as a *JSON* formatted object.

include example

- Second, is the core of the meta-model, which is a model expressing the computation itself, and since node-red is the chosen platform to execute our computation on, then naturally, it is modeled into a *flow*, which is a model used by node-red to describe the capabilities and actions of a computation in JSON format. This simplifies the whole idea of making the computation meta-model travel through the network, because with node-red, the maintainer could develop a computation using the user interface of node-red, then export this computation as a flow, include the meta-data and publish it to the network. Afterwards, a node can read the meta-data and analyze if it could run this computation according to its resources, then import the flow into its node-red instance and deploy it for running. **include example**

- Last aspect in the meta-model is the output or results of the computation run. Since the node does not know what kind of data does the computation produce, therefore the maintainer must specify the way the output data is used or stored. In this case, nodes can understand whether the data needs to be sent back to the original node or just stored in a local database for further use.
  include example

3.4.1.1 Dealing with Dependencies (Shipping, Configuring)

3.5 Moving Data

3.5.1 Data Streaming

we can ask the hight performance units to stream from cameras no low devices. but how to do it ?

3.5.2 Explain data distribution among several nodes to apply pervasive computing

3.5.2.1 Input Meta-data

is it local, provided or collected data.

3.6 Networking

3.6.1 SCAMPI

3.7 System Design

A System Design can be broadly described as an architecture of the system, which includes an explanation of each and every hardware component of the system, the connection between these components if there is any, and the data flowing between these components. Moreover, it provides a wide glimpse of the whole system but not its exact functionality, hence, giving a simple understanding of the architecture without jumping into much detail.
Initially, the components of the System Design is introduced, then, the connection between these components is shown, and eventually, the flow of the data is pointed out.

3.7.1 Components

Below, each component of the proposed system design is explained.

3.7.1.1 Node

A Node is one of the core components of this design, it is a small computer device of low storage and computation capacity compared to nowadays portable computers, commonly a *Raspberry Pi* but could be any other device. It is connected to several sensors which typically detect certain changes in the environment and converts it into digital data, for instance, Gas sensor, Temperature sensor or a Camera. Then, the device either stores the data into a local database, performs a computation locally, does both or even asks other nodes to do computation instead, however, an assumption about which sensors or specifications does a specific node possess can not be made, meaning, each node might not have the exact number or types of sensors because each node may be deployed in a different timing or context. Thus, each node has a configuration file specifying its capabilities. A typical node is shown in figure 3.1

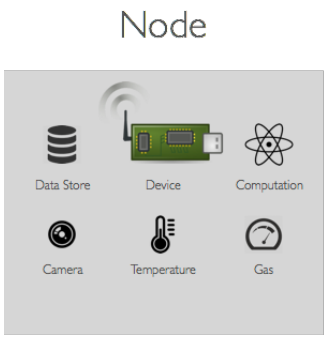

Figure 3.1: A typical node in the system

3.7.1.2 High PerformanceGraphics Processing Units

A High Performance UnitGraphics Processing Unit *GPU* is a device with massively parallel architecture designed to handle multiple tasks at the same time, thus observed to be much faster and more efficient than a Central Processing Unit *CPU*, and in turn, has higher computation capabilities than the CPUs in the proposed system nodes in 3.7.1.1. An example of a high processing unit is a Graphics Processing unit *GPU*.

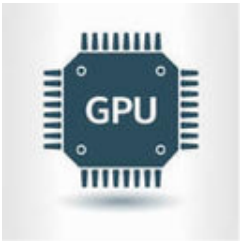

Figure 3.2: Figure denoting a Graphics Processing Unit GPU

3.7.1.3 Network

A Network in this design is a set of connected components which are capable of communicating and therefore allowing data sharing between them.

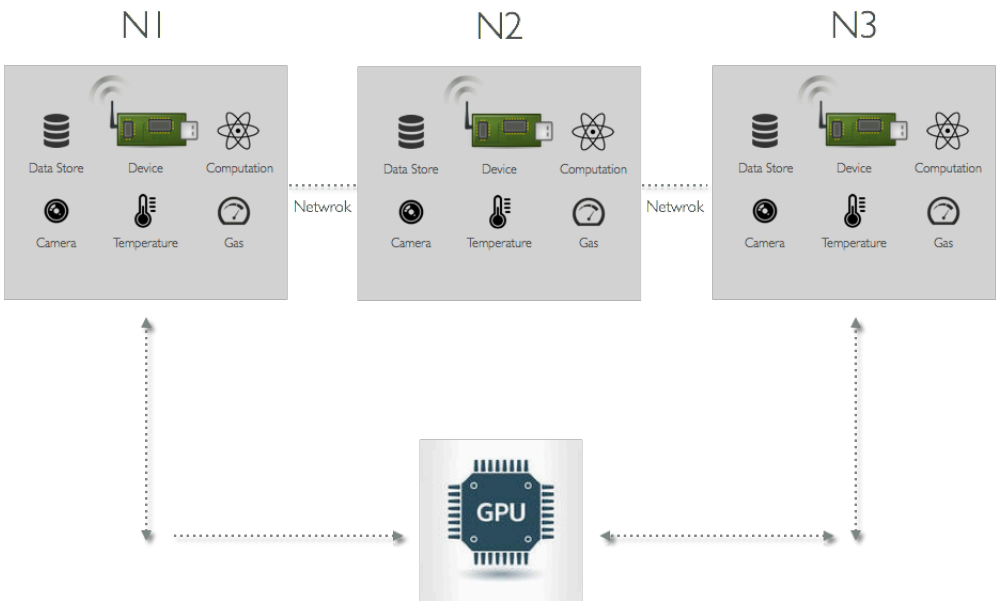

Figure 3.3: A network consisting of three connected nodes and a GPU

– TODO: Emphasis the difference between persistent and non persistent network links in system design.

3.7.1.4 Mobile Device

A Mobile Device in this context is any device that can connect to the network containing the nodes and is allowed to carry data from one network to another, hence, allowing a form of data sharing between networks or nodes which are not connected.

Figure 3.4: Figure denoting a Mobile Device

3.7.2 Connectivity and Data Flow

A Network described in 3.7.1.3, is a simple form of connectivity between components, however, components and specifically nodes are not necessarily connected, sometimes they are just a standalone component that cannot share any information via direct connectivity, also, networks could be disconnected as well, meaning, a network might

not be connected to the whole system, thus, is a standalone network. In these cases, a mobile device could help in carrying information and data between these disconnected nodes or networks.

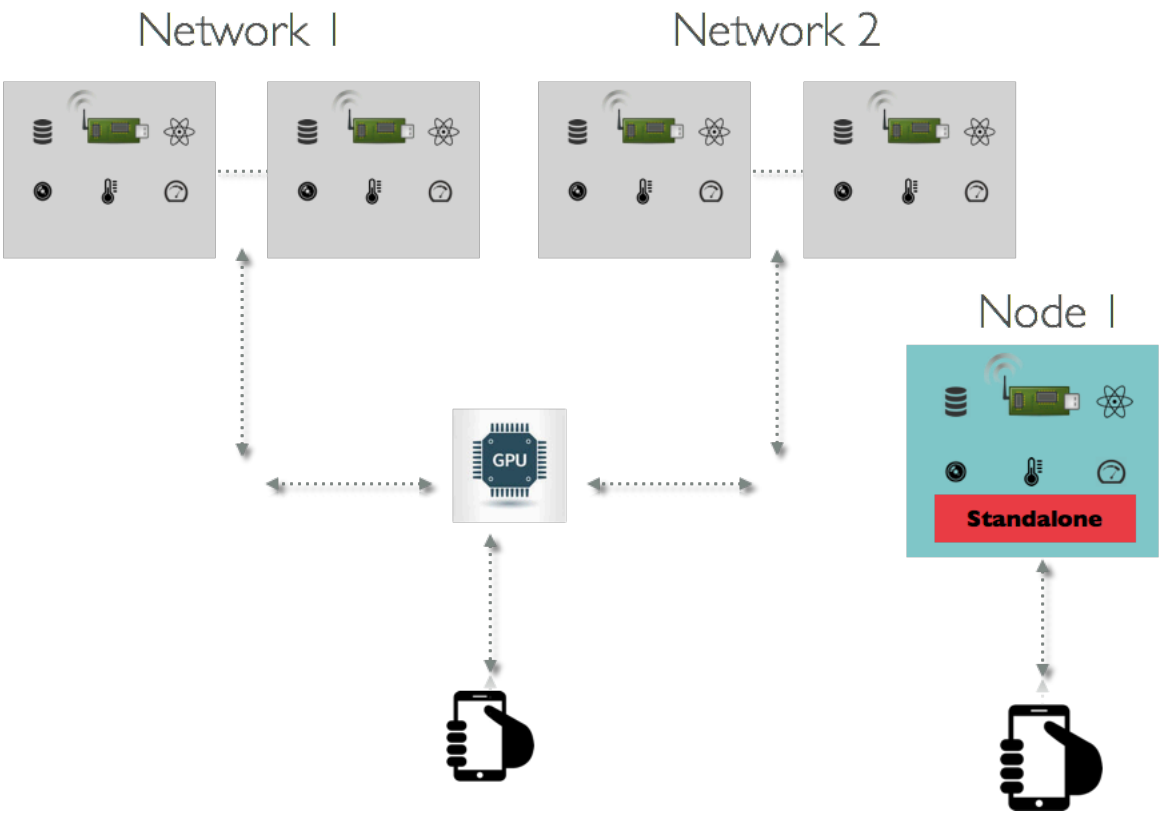

Figure 3.5: Two networks connected with a GPU and one standalone network

3.8 Summary

4 Evaluation

4.1 Implementation

4.2 Use Cases

Design of two, three or more use cases, however, implement one or two.

4.3 Performance Tests

4.4 Limitations

5 Conclusion

5.1 Summary

5.2 Future Work

5.2.1 Streaming API