Composition in the Web of Things
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Introduction
The Internet of Things is an emergent paradigm that foresees heterogeneous devices being able to interact with one another to achieve certain goals. Current forecasts say that there will be from 26 billion to 75 billion devices connected to the Internet by the year 2020, up from about 5 billion as of 2015 (Riggins & Wamba, 2015). These devices, more commonly referred to as ‘things’ in the IoT context, and the networks that they form can be compared to disconnected islands of inhabitants speaking different languages, unable to communicate with each other due to the disparity of languages and communication protocols. This presents a system integration problem on an extremely large scale, making it rather difficult to solve using enterprise approaches due to the disparity of languages and communication protocols. The Internet of Things (IoT) offers a great premise enabling a multitude of useful automation scenarios by leveraging existing web technologies, as well as advances in hardware and software abstractions that make it cheaper and easier to develop web enabled, atomic Things that can form bigger and more complex systems. The next steps involve expanding the WoT testbed by adding more web-enabled heterogeneous devices to it and evaluating discovery, linking and composition mechanisms within WoT.

The Web of Things
The Web of Things (WoT) is an approach to realizing the IoT that leverages current web infrastructure and its open standards and technologies that together have solved the integration problem for heterogeneous networks and devices at the application layer in the networking stack, while staying agnostic to the lower layers and their implementations. It builds on the idea that each ‘thing’ will be running a web server software (utilizing the HTTP protocol and adhering to the REST architecture for increased interoperability) if integrated directly (smallest web server implementations require less than 50KB of RAM) - indirect integration is possible through more computationally capable devices (gateways) for resource constrained devices that use more lightweight protocols such as CoAP. The Web of Things approach encourages software developers and vendors to use open web standards to provide a uniform interface to those devices, which prevents vendor lock-in and can potentially be leveraged in building complex distributed applications more easily; also providing scope for research work into automatic and autonomous behaviours that are not bound to proprietary protocols. Also, the existing infrastructure provides an excellent platform to build upon as resources can respond with representations in the HTML format that can be rendered in any browser, on any device and used as a user interface.

The Semantic Web
Semantics play a critical role in the WoT - knowledge representations that are meaningful for humans can be ambiguous and ultimately useless for machines trying to draw logical inferences about the data they are trying to process. The semantic web is an extension to the web that encourages the use of common vocabularies (ontologies) to describe and link data in a markup fashion. Marking up resources with metadata using common ontologies such as SensorML can aid in automated discovery of resources and composition by making information accessible to autonomous agents (Talantikite, Aissani, & Boudjlida, 2009).

Automatic generation of physical mashups
There exists scope for research work into automatic mechanisms that exploit the assumption of a uniform interface, the semantic web and AI planning techniques. The hypothesis is that it is possible to take the atomic resources exposed by individual ‘things’ to generate meaningful mashups that would increase the level of automation in various scenarios. A very simple example has been provided by Tim Berners-Lee et al. in a publication on the semantic web, whereby Things exposing a speaker resource can be turned down when a phone is answered. That would be achieved through a complex service that had been automatically generated by an autonomous agent through discovery and composition mechanisms, though in the original writing this generation process was depicted as a manual process (Berners-Lee & Laslila, 2001). The aim of current work is to create an ecosystem of web ‘things’ as a platform for exploring existing solutions to the problem as well as concepts and ideas existing in the literature to evaluate whether they would naturally map onto the physical world.

Rationale
Manual generation can be achieved by providing code that glues together atomic modules or through the use of mashup applications with GUIs (at the cost of flexibility). Adaptable and autonomous services composition, however, is still an open problem (Sheng et al., 2014). Testing hypotheses with regards to adaptability and autonomy will also necessitate a mechanism that would define the functional requirements that could be leveraged to generate physical mashups.

Conclusion and future steps
An overview of on-going and future work has been provided with the rationale for research effort in this particular area. The Internet of Things offers a great premise enabling a multitude of useful automation scenarios by leveraging existing web technologies, as well as advances in hardware and software abstractions that make it cheaper and easier to develop web enabled, atomic Things that can form bigger and more complex systems. The next steps involve expanding the WoT testbed by adding more web-enabled heterogeneous devices to it and evaluating discovery, linking and composition mechanisms within WoT.

References

Figure 1: The benefits of a uniform HTTP interface, visualized

Figure 2: A web-enabled Raspberry Pi board equipped with Wi-Fi communication interface, temperature and motion sensors and LED actuators, built for evaluating Web of Things concepts. This particular RPI runs a simple web server built using Node.js. RPI makes for an ample resource that can be utilized as a gateway for resource constrained devices.