There is enormous growth in the number of ‘things’ that incorporate sensors to capture data, photos and video and that can interact with people, IT systems and other things directly using Internet connectivity. Devices with these capabilities are becoming commonplace in homes, streets, cars and workplaces. The potential benefits and risks that arise have resulted in the Internet of Things (IoT) emerging as a critical area of interest to policymakers. Many countries, including the UK, now regard the IoT as highly significant for achieving economic growth. Additionally, consumers have a growing awareness of the connected devices and sensors that are a part of the IoT, mainly through their domestic equipment, such as smart TVs and Internet-accessible home security systems and control systems for heating and lighting. It is evident that the IoT holds the potential for major economic opportunities across a wide variety of consumer and industrial sectors; however, there are important policy issues that affect the development and adoption of the IoT across these sectors.
The research

With the IoT continuing to grow and develop at a rapid pace, there is a need to use evidence from real world examples of IoT implementations and to understand consumer attitudes in order to help inform policies around the IoT. The central aim of our study, commissioned by IoTUK and BCS, The Chartered Institute for IT, was to support a process for policy feedback that will inform the development and adoption of the IoT in the UK. In order to achieve this central aim and to gain a rounded picture of the potential policy implications of IoT developments in the UK, we adopted a bottom-up approach that allowed us to develop a better idea of what is happening ‘on the ground’ in the UK through insights from businesses and informed users of technology.

**Real world IoT case studies**

We looked at nine real world examples of IoT implementations in the UK that were previously identified by IoTUK, and we examined their policy implications. These case studies involved consumer and industrial applications across a wide range of sectors, such as healthcare, energy and environment, transport, retail and agriculture, and they represent examples of applications that have moved from development to deployment. Studying specific IoT case studies in depth offers a way to understand what is happening at the frontier of IoT industrial activity in the UK.

**Survey of informed users of technology**

We carried out a focussed online survey of informed users of technology to gauge their awareness and understanding of the key policy issues related to the advancement of the IoT in the UK. The survey helped us gain a sense of what a sector of the public that is familiar with the technology and its implications thinks about such issues as the applicability of IoT to specific sectors, the benefits and risks of using IoT-related products and services, and the role of government in supporting the IoT as a strategic industry in the UK.
Geographic locations of the nine IoT-related case studies examined in the study

- **Travelling in the North East:** The ‘Pop Card’ smart ticketing and payment platform
- **Farm herd sensing:** Connecting farmers to their herds through sensors
- **Smart bins as a service:** ‘BigBelly’ solar powered bins come to Nottingham
- **Smart parking in Westminster:** Smart parking made open for the community
- **London City Airport demonstrator:** Creating a connected retail space
- **Breathe Heathrow:** Using open data to help the public understand air quality and noise impacts
- **Advancing telehealth in the North East:** Benefitting patients and families with simple telehealth solutions
- **Opening a city:** An R&D testbed in Bristol that can be used for city scale trials
- **Connected lighting on the South Coast:** Smart street lighting controlled through a central platform
Every IoT device is potentially hackable. For medical appliances, this could be extremely dangerous. There are so many unknown consequences at this point.

There are a lot of people now developing solutions and eager to implement them, but there is a caution on the side of the buyers.
Based on these opportunities and challenges, our study attempted to support policy communities (including national and local government policymakers, industry, innovators, academia and the public) through describing a set of wide-ranging policy objectives and associated priority topics for further discussion and exploration. Specifically, we identified four themes for action, aimed at:

- **Supporting research and innovation in the IoT ecosystem**, by (a) focussing on non-technical factors that drive adoption and (b) sharing knowledge from previous IoT-related projects, helping researchers and businesses avoid reinventing the wheel.

- **Stimulating greater demand for the IoT to be adopted more widely**, by creating opportunities to use IoT solutions at the core of the delivery of public services.

- **Strengthening infrastructure and framework conditions for the development and adoption of the IoT as a systemic innovation**, by (a) promoting greater interoperability and information sharing across applications and (b) supporting the use of integrated IoT infrastructure across sectoral boundaries to help scalability.

- **Mitigating the risks of a pervasive IoT**, by (a) supporting a trusted, people-centric IoT ecosystem and (b) addressing concerns about the potential risks of IoT technologies to critical national infrastructure.

The infographic shown overleaf depicts each of the proposed priority topics for consideration, clustered by policy objective, along with some supporting policy questions. These questions are wide ranging, and they horizontally apply across different sectors and industries. The required responses to these questions are unlikely to be achieved by public policy or industry alone; instead, they may require an active, multi-stakeholder approach.

> Development of the IoT should involve people who are actually affected by the technology.

> Our product started with a problem and then we looked at how technology can address this problem.
Proposed priority topics for discussion and the associated key policy questions

- What can the policy community do to support the systematic assessment of risks associated with innovative IoT technologies and their deployment in public infrastructure?
- How can current contingency plans be enhanced to identify and manage security risks associated with a growing and pervasive IoT?
- How can the policy community help industry balance economic objectives with creating an IoT ecosystem that is more open, trustworthy and inclusive?
- How can the recognised processes for certifying devices be adapted to deal with the specific trust challenges posed by the IoT, including consent and information governance?
- How can the policy community incentivise industry to adopt people-centric design and development?
- What steps can be taken to raise cyber awareness and educate citizens about the potential benefits and risks associated with the IoT?
- How can public procurement processes support the use of open IoT-enabling standards and interfaces in order to gain the critical mass?
- How can sectorspecific public investment initiatives work together to ensure that tested technologies are applied to new contexts and that systemic benefits are realised?
- What steps can be taken by the policy community to create opportunities for effective collaborative networks involving citizens, industry, academia and government?
- How can the policy community support the use of IoT technologies for critical national infrastructure?
- How can publicly funded smart city and large-scale demonstrator projects support the drive towards common standards?
- How can public procurement processes support the use of open IoT-enabling standards and interfaces in order to gain the critical mass?
Concluding remarks

The IoT is a rapidly evolving area that has implications for a wide range of industry sectors and stakeholders, especially the public. From our research, it is clear that the development and adoption of the IoT presents a number of promising opportunities, particularly in its potential to deliver positive socio-economic benefits, but that there will also be several challenges, particularly around security, privacy and trust. Crucial questions raised in this study will need to be directly addressed through policymaking in the future. These questions relate to how the UK can most effectively enable the deployment of IoT products and services to foster business opportunities and shape the IoT marketplace, while creating public trust and confidence in the principles by which the IoT is governed. The first steps in this direction might involve addressing the questions raised here concerning setting the right framework conditions that ensure long-term growth for the IoT, as well as recognising and understanding the nature of the IoT as a systemic innovation requiring funding, standards, evidence and trust.

We have closely examined the public policy implications of real IoT implementations and user perspectives to provide input to a feedback loop for the whole IoT policy community. We hope that using this bottom-up approach to engage with and examine the role of two key groups of stakeholders in the IoT ecosystem – businesses and individual users of technology – has generated deeper insight for the policy feedback loop. We also propose that the method we deployed in this study can be used in the future to provide a continuous feedback mechanism on how the impact of IoT-related policy is progressing in the UK.