Feed me, Feed me: An Exemplar for Engineering Adaptive Software

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Feed me, Feed me: An Exemplar for Engineering Adaptive Software

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ABSTRACT

The Internet of Things (IoT) promises to deliver improved quality of life for citizens, through pervasive connectivity and quantified monitoring of devices, people, and their environment. As such, the IoT presents a major new opportunity for research in adaptive software engineering. However, there are currently no shared exemplars that can support software engineering researchers to explore and potentially address the challenges of engineering adaptive software for the IoT, and to comparatively evaluate proposed solutions. In this paper, we present *Feed me, Feed me*, an exemplar that represents an IoT-based ecosystem to support food security at different levels of granularity: individuals, families, cities, and nations.

We describe this exemplar using animated videos which highlight the requirements that have been informally observed to play a critical role in the success or failure of IoT-based software systems. These requirements are: security and privacy, interoperability, adaptation, and personalisation. To elicit a wide spectrum of user reactions, we created these animated videos based on the ContraVision empirical methodology [23], which specifically supports the elicitation of end-user requirements for controversial or futuristic technologies. Our deployment of ContraVision presented our pilot study subjects with an equal number of utopian and dystopian scenarios, derived from the food security domain, and described them at different levels of granularity.

Our synthesis of the preliminary empirical findings suggests a number of key requirements and software engineering research challenges in this area. We offer these to the research community, together with a rich exemplar and associated scenarios available in both their textual form in the paper and as a series of animated videos (http://sead1.open.ac.uk/fmfm/).

CCS Concepts

•**Software and its engineering** → *Software system models;*
•**Social and professional topics** → *Software selection and adaptation;*

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Keywords

Requirements, Internet of Things, mediator synthesis, feature models, collaborative adaptation

1. INTRODUCTION

Software engineering researchers often rely on exemplars to drive, communicate, compare, and evaluate their research and results [15]. Many of the well known exemplars, such as the meeting scheduler [32], lift management system [24], and railroad crossing control [17], have served the research community well over the years. However, the complexity and scale of modern software-intensive systems is such that these exemplars no longer serve their purpose of challenging software engineering researchers to address current challenges such as the integration and interoperability of multiple systems, complex and emergent security and privacy requirements, the interplay between digital, physical and social concerns, and the need to support dynamic (runtime) adaptation. Many researchers have sought to address these challenges in the context of bespoke application scenarios and case studies that vary between research projects and groups. No more so is this apparent than in the context of the Internet of Things (IoT).

The IoT presents a major new opportunity for research in adaptive software engineering. The IoT promises a future where devices and people interact seamlessly with one another, and with their environment, to access targeted, optimised, and adaptive services, due to changes in needs, desires, and context. Realising the IoT requires addressing many challenges, including the support for software adaptation [1, 10]. In this paper we propose an exemplar, called *Feed me, Feed me*, to explore the challenges and requirements of modern IoT systems. The purpose of the exemplar is to capture a variety of requirements for engineering adaptive software for the IoT.

Feed me, Feed me is an IoT-based ecosystem to support *food security*; that is to ensure sufficient, safe, and nutritious food to the global population [13]. We describe *Feed me, Feed me* at four levels of granularity, namely (i) personal, (ii) family, (iii) community, and (iv) nation. At the personal level, smart devices monitor, analyse, and provide suggestions around an individual's activities, health, and nutrition. At the family level, smart home appliances collaborate to devise meal plans that takes into account nutritional needs, preferences, and personal goals for each family member. At the community level, local supermarkets collect real-time data about the grocery needs of multiple families in order to manage their stock efficiently and reduce food wastage, as well as to increase their business value. At the national level, food producers and food manufacturers use the data collected from different local supermarkets to predict food needs accurately and decide on alternatives in case of a food crisis.

The *Feed me, Feed me* exemplar highlights several desirable characteristics of IoT-based adaptive software systems. Our goal is to elicit and formulate end-user requirements for IoT-based adaptive software that can contribute to ensure food security and identify the research challenges when engineering adaptive software. We chose to describe this exemplar using animated videos, which we think lead to better communication with stakeholders. We initially focus on understanding user expectations, rather than software engineers. To further focus our investigation, the animated videos highlight the requirements for IoT systems recurrent in the literature [1, 10]: security and privacy, interoperability, adaptation, and personalisation. These videos serve two purposes: (i) to describe the exemplar to the community of adaptive software engineers, and (ii) to assist with the elicitation of additional requirements and research challenges.

To maximise user feedback, we created these animated videos based on the ContraVision empirical methodology [23]. ContraVision uses two comparable scenarios that highlight the positive and negative aspects of the same situation. The goal of ContraVision is to elicit a wide spectrum of user reactions for potentially controversial or futuristic technologies. We developed an equal number of positive and negative scenarios and presented these scenarios to groups of people in order to help us elicit the requirements and identify the research challenges for engineering adaptive IoT-based software. The initial results of our pilot study confirmed our initial set of identified requirements and research challenges, emphasised some social aspects that need to be considered in the IoT technology when used to support food security, and demonstrated some trade-offs between control and automation necessary for these technologies to be adopted.

We believe that IoT technologies provide an important opportunity for the adaptive software engineering researcher community to experiment and to evaluate its work. At the same time, IoT technologies can also benefit from adaptive software engineering research. We provide the *Feed me, Feed me* exemplar (http://sead1.open.ac.uk/fmfm/) to the Software Engineering and Self-Adaptive Systems community to support research and comparative evaluation in this area.

The rest of this paper is structured as followed. Section 2 presents the food security problem and describes the *Feed me, Feed me* exemplar in more detail. Section 3 examines the challenges often presented as important for engineering IoT-based software systems. Section 4 presents a set of representative scenarios that illustrate the use of the IoT for addressing this problem at different levels of granularity. It also reports on our preliminary empirical work to validate the scenarios and elicit end-user requirements. Finally, Section 5 discusses the challenges of engineering IoT-based adaptive software and suggests areas for future research.

2. FEED ME FEED ME: AN EXEMPLAR

The 1996 World Food Summit stated that food security would exist when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food [13]." With an ever expanding global population the need for food security is becoming more urgent. Much of the debate focuses on the production and distribution of food on a national and international scale. These are just two components of a much richer and more complex techno-socio-economic issue. The challenge of food security begins in the field and ends at the dinner table. In between is a vast set of social, economic and engineering challenges that need to be met to ensure that all 9.22 billion people expected to be inhabiting the earth by 2075 [26] have access to sufficient, safe, nutritious food. For food security to be established we need to address inefficiencies in all the layers of Figure 1.

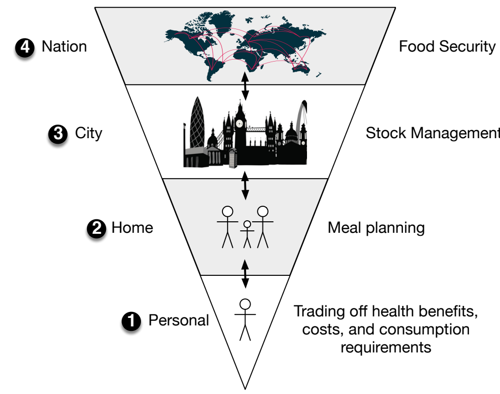

Figure 1: IoT Food Security Challenges

❶ *Personal.* The ultimate driver of the adaptation in the chain is the individual. Cultural shifts and education are required to reduce an individual's likelihood to waste food [36]. This includes better diet, meal and food management by the individual. Diet and meal management includes reducing over consumption and wastage of food. Technology has progressed sufficiently that wearable devices are now able to do a myriad things. They can detect caloric and nutritional consumption and accurately calculate activity levels and caloric expenditure. Accurate caloric expenditure and health goals can drive adaptation in a smart home. Depending on the individual's daily activities and consumption, automated systems can alter meal plans to help individuals achieve their goals.

❷ *Home.* In 2008, UK households wasted 6.7 tonnes of food [33]. This represented 25% of all food purchased by consumers in the UK. Most of the food that is wasted include perishables, bread, meat, and diary. Studies [36] highlight that two of the biggest factors that contribute to food wastage are over-preparation (cooking too much for example) and spoiling. Smart packaging and adaptive appliances can keep an up to date inventory of families' food. It can provide families with notifications of what food is expiring as well as suggest meal plans that give priority to ingredients that are going to expire. Meal suggestions can also adapt to families' health goals, daily schedules and dietary requirements. Smart appliances can communicate with supermarkets and provide grocery requirements.

❸ *City.* In December 2015 the French National Assembly voted unanimously in favour of a law which required supermarkets to give unused food to charities [29]. Wastage in supermarkets is mostly a supply chain management issue. To maximise product availability, supermarkets over stock items, which are then disposed of after reaching their sell by date. Better planning and collaboration in the supply chain as well correctly predicting demand due to external factors such as weather can reduce waste [36]. Combining communities' food requirements can provide supermarkets with invaluable information about how much stock they require in different stores in different parts of the country. This information collected and aggregated at the local, city, regional, and national level provides manufacturers and distributors with real time and accurate inventory requirements which if used effectively can dramatically reduce food wastage on the shelves.

❹ *Nation.* On a global level, food wastage occurs primarily due to overproduction in the field. Up to 50% of food is lost between the field and the dinner table [22]. In 2007 the UK's Department for Environment, Food & Rural Affairs estimated that contractual penalties and poor forecasting of demand led to 10% overproduction [14]. Much of this overproduction is left to waste in the field. An overview of the entire food production ecosystem would allow farmers to exploit under production of certain produce. At this time many farmers over produce as an insurance policy against low yields. With IoT technology real time data may prevent the need for over production and reduce field wastage. This includes better forecasting of demand and output. It could revolutionise how contracts are negotiated between the producers and the supermarkets.

To sum up, at each of (and between) the four layers described, an adaptive IoT solution could have a significant impact on reducing global food wastage. Much of this technology already exists within the food chain, including logistic platforms used by distributors and supermarkets, smart appliances used in homes and smart technology used by individuals. Based on the food security issues that we have highlighted we can envisage how technology can fit into these four layers to reduce food wastage. However, to unleash the full potential of IoT technology, several challenges have to be addressed, any of which lie in the engineering of adaptive software. In the next section we describe these challenges as they are usually presented in the research literature. In Section 4 we focus on eliciting them from an end-user perspective.

3. IoT RESEARCH LANDSCAPE

The IoT raises many research challenges for many disciplines of which a complete survey is beyond the scope of this paper. We refer the interested reader to one of the many surveys on the subject [3, 4]. In this section we focus in this section on the general challenges that often arise in the context of engineering IoT-based (adaptive) software systems [1, 10].

Security and Privacy. As the number, complexity, and heterogeneity of connected devices and people in the IoT increases, so does our need for security and privacy. Secure systems must provide the necessary capabilities to protect assets from intentional harm. These systems rely on an explicit definition of their security requirements to describe precisely which actions in a system are allowed and which ones are prohibited [31]. Defining those security requirements necessitates scoping the problem by specifying the stakeholders involved, the assets and their values, and the potential threats. The IoT makes this definition harder by not only widening the scope (and thus extending the attack surface [12]) but by making it dynamic and uncertain. The IoT also produces vast quantities of data, a lot of which is personal in nature, therefore the need to implement robust privacy protection is critical [10].

Interoperability. One of the fundamental challenges of the IoT is to compose the capabilities of the plethora of devices. This challenge is exacerbated when heterogeneity spans the application, middleware, and network layers. At the application layer, devices may exhibit disparate data types and operations, and may have distinct business logics. At the middleware layer, they may rely on different communication protocols, which define disparate data representation formats and induce different architectural constraints. At the network layer, data may be encapsulated differently according to the network technology in place. While standardisation efforts such as HyperCat [18], IoTivity [21] and AllJoyn [20] are suggested as potential solutions at the network and middleware layers, the diversity of IoT applications requires additional effort to deal with semantic interoperability at the application layer [19].

Adaptation. Change is inherent in the IoT due to the mobility of the devices and people as well as the diversity of its applications and their use. To deal with change, software systems must adapt their structure, behaviour, and security mechanisms [11]. Incomplete knowledge of the physical environment, the uncertainty of human behaviour, the multitude of stakeholders, and changing goals make such adaptation particularly challenging [35].

Personalisation. The ultimate goal of the IoT is to provide every person with targeted, optimised, and adaptive support to fulfil their specific needs, and to achieve their social and professional goals. This requires software able to capture and accurately represent and reason about people's individual behaviours, moods, and intentions [28]. Adaptive user interfaces [2] aim to engage users by providing them with personalised experiences and new ways to interact with ubiquitous computing technology. Self-quantification provides the means to monitor users' attention [16] and emotions to provide personalised interaction [9].

While software engineers have formulated research challenges of engineering adaptive software for IoT in terms of the concerns above, the challenges are not as easy to grasp by lay users. In the following section, we present the *Feed me, Feed me* exemplar empirically, to highlight these challenges in an accessible narrative form.

4. FEED ME, FEED ME: A PILOT STUDY

The ContraVision empirical methodology [23] uses two identical scenarios that highlight the positive and negative aspects of the same situation. The goal of ContraVision is to elicit a wide spectrum of user reactions to potentially controversial or futuristic technologies. To pilot the suitability of our exemplar, we developed an equal number of positive and negative scenarios and presented them to different groups of people in order to help elicit requirements and identify the research challenges of engineering adaptive IoT-based software. In the following subsections we describe the scenarios, how we conducted our preliminary study, and our initial empirical findings.

4.1 ContraVision Scenarios

Based on the ContraVision methodology, we produced two videos, each of which depicts an end-to-end IoT food security system involving the four levels of granularity described in Figure 1. The main protagonist of the videos is Charlie, a 30 year old father of two children. Charlie and his family use several IoT-based software systems in their daily lives, including sleep monitoring, activity and calorie tracking devices, and smart appliances. We present below the various systems associated with different parts of the scenarios together with a description of the positive and negative scenarios associated with those systems. We elaborate each scenario describing the positive and negative perspectives.

Analyse Me. The first scenario highlights Charlie's relationship with the technology and how it may impact his behaviour. The scenario describes how Charlie uses his fictional personal tracking system *Analyse Me*. Charlie wears a device that tracks his heart rate, blood pressure, blood glucose, food intake, sleep, and activity levels. The device provides Charlie with notifications that adapt to changes in his mood, activity levels, and food consumption. He uses the device with the assumption that it will enable him and his family achieve particular health and fitness goals.

Figure 2: Charlie and his smart devices

Positive	Negative
Charlie embraces the technology and uses it to improve his health and well being.	Charlie becomes obsessive about the technology.
Charlie gets a restful night's sleep.	Charlie spends hours analysing his sleep and fitness data. This affects him so much that he loses sleep at night.
When he has breakfast, *Analyse Me* informs him about his calorie intake.	When Charlie skips breakfast, *Analyse Me* warns him that his calorie intake is zero.
At work, *Analyse Me* notifies him when it is time to eat.	At work, *Analyse Me* keeps nagging him to have something to eat. His colleagues notice that he is distracted at work.
At the gym, thanks to feedback from his devices he is able to achieve a personal record on the treadmill.	At the gym, while obsessing over his heart rate on a treadmill, Charlie falls over.

Home Hub. The second scenario focuses on Charlie and his *Home Hub*, a smart system that communicates with the smart appliances in his home. With the aid of smart packaging, the refrigerator and pantry send their contents to *Home Hub*, which keeps track of the family's food consumption requirements. This allows the family's meals to be planned in advance and gives the supermarket a list of required ingredients and when they are required. The family's grocery list can be adapted depending on various preferences such as price, locality and environmental impact. *Home Hub* acts as a mediator between different smart devices and Charlie's local supermarkets. In the event of changes in the normal family routine (e.g., a guest arriving unexpectedly for dinner), the meal plan is automatically updated to accommodate the guest's dietary requirements.

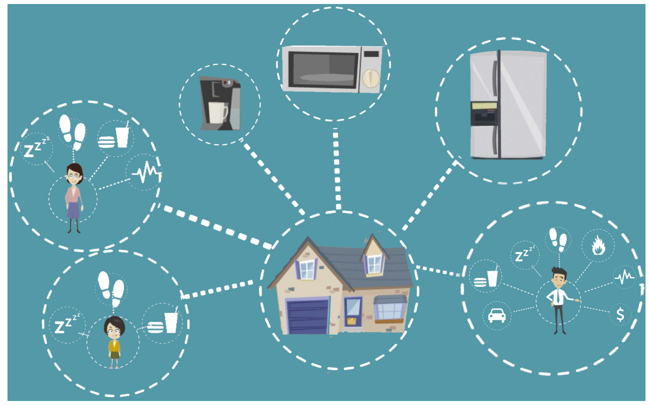

Figure 3: Charlie in his smart home

Positive	Negative
Uncle Frank arrives unexpectedly and is invited to dinner. On that particular evening the meal planned was spaghetti and meatballs. However, Uncle Frank has a gluten sensitivity. Therefore, HomeHub adapts and Uncle Frank has steak for dinner.	
Charlie is relieved not having to update the meal himself and is happy to have a system that can adapt so easily.	Charlie is upset as he does not understand why Uncle Frank can have steak and he is still having spaghetti and meatballs.

Smart City. The third scenario highlights the practical use or misuse of the real-time data collected by IoT systems. In this scenario, Charlie and all his neighbours use *Home Hubs*. This allows supermarkets to gather real time data about communities' grocery requirements, and consequently better manage their stock and inventory. As the supermarkets collect accurate data about their customers, they provide them with targeted offers and promotions. They also implement a surge pricing model, which makes groceries cheaper or more expensive depending on demand.

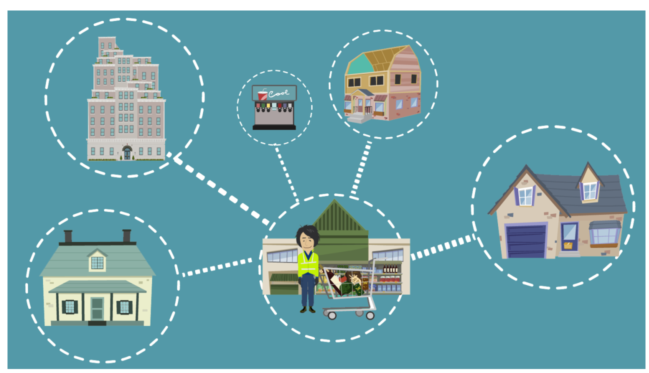

Figure 4: Charlie, his neighbours, and their smart supermarket

Positive	Negative
The supermarket adds some free items to Charlie's grocery delivery.	
Charlie is grateful for the supermarket including free products for him and his family to try. Lucy, Charlie's daughter, really likes the chocolate the supermarket has included.	Charlie is furious as the price of some grocery items have increased. He does not pay attention to Lucy, his daughter, while she eats the free chocolate the supermarket has included.

Smart Nation. The fourth scenario highlights large-scale collaboration between IoT systems. The food requirements of

Charlie and his neighbours are aggregated by supermarkets and provided to food manufacturers, producers, and distributors. This enables better management of food production processes. Combining real time weather, crop health, and consumer demand data, producers are able to make better forecasts about their production yields. This reduces over production.

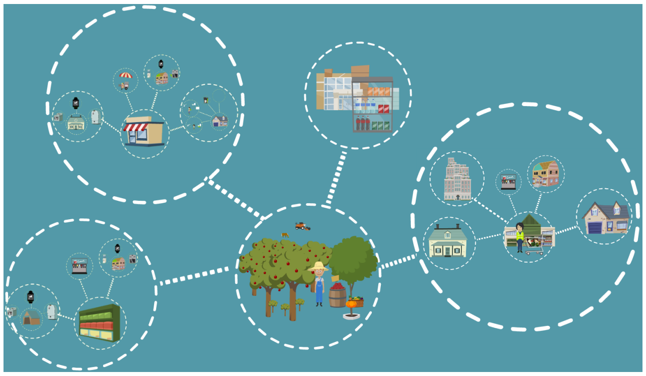

Figure 5: Charlie and his planet/smart nation

Positive	Negative
The introduction of IoT technology has helped farmer Joe reduce costs and improve yields. As a result he is able to produce food more efficiently and become more profitable.	Farmer Joe is not able to install the infrastructure required to be part of this new adaptive IoT system. Big Farm Inc. is able to invest heavily and eventually puts farmer Joe out of business.

4.2 User Study

We conducted a preliminary study involving 11 participants, of mixed ages, genders and backgrounds, divided into two groups. The first group contained five participants and were shown the positive version of the scenarios. The second group contained six participants and they were shown the negative version of the scenarios. Showing two versions to different groups enabled us to get a wider range of views from the participants in the study. During the study, participants watched the video and then participated in a 20-30 minute facilitated group discussion, and individually completed a short questionnaire. Each video was approximately three minutes long and split up into four chapters. The group discussion was guided by five questions aimed at helping elicit as much information from the participants as possible.

The questions helped the investigators guide the discussion, while the questionnaire contained general questions about individuals' background, life style, and use of technologies, as well as questions about individuals' trust of technological devices, future use of technology to support the Feed Me, Feed Me the scenarios, and individuals' privacy requirements and concerns. The resources of the study are available at http://sead1.open.ac.uk/fmfm/.

4.3 Findings

We found that each group had a number of similar concerns about the technologies in the videos. *Trade-offs* were a recurring theme in both of the discussions. These included trade-offs in privacy, automation, control, and customisation. Many of the participants were receptive to the idea of the adaptive IoT system presented in the videos. Some of them remarked that it was not drastically different from what was already available without the adaptive and automatic components.

Within both groups, around half the participants indicated that they would use such systems. A few said they would take a wait-and-see approach, with the rest voicing a number of practical concerns about using such systems. In the following we present the themes that were discussed during the study and the comments from some of the participants. These comments are identified below with prefix 'P', for the participants from the group shown the positive video (which we call the 'positive group' for brevity); and prefix 'N', for the participants from the group show the negative video (the 'negative group').

4.3.1 Security & privacy

Privacy versus benefits. This was a recurring theme in both groups, however in the negative group it was a more substantive focus of the discussion. Although some participants felt that providing data to improve the accuracy of recommendations was beneficial, some thought that revealing personal information was a step too far: *"I don't want them knowing what's in my cupboard"* (P2). Others were happy to share data if they gained some benefit. *"to some people that could be quite useful, ... , having something to make those decisions for them would be helpful"* (P1); *"They don't know what I have in my cupboard now but I would find that useful if they did because I forget [when ordering grocery online], I wouldn't mind that at all"* (P4). There were comparisons made between recommendations and targeted advertising. Those in both groups that had prior privacy concerns felt that this aspect of the recommendations was not beneficial, while those with fewer privacy concerns preferred this. *"There are undoubtedly benefits that can be given but the downside... a lot of the time the downsides are always greater somehow, less trust"* (N1); One participant explicitly stated that they would prefer a *"hybrid"* (N6) approach.

Sensitive versus shareable data. Participants in both positive and negative groups distinguished between data they would share and data they would not share. Most of the viewers were happy to share health and fitness data (e.g., steps, activity levels, sleep). However, both positive and negative participants would not be prepared to share more personal types of data; *"I'm happy to share my eating and sleeping habits, I won't say financial"* (N5); *"It's just your pulse and I guess how long you sleep things like this I wouldn't have a problem at all."* (P4).

4.3.2 Interoperability

One aspect of the videos that was emphasised was how the supermarket was informed that a particular grocery item was running low. This prompted the participants to ask about the interoperation of the different systems involved in the food security management chain. *"Do the supermarkets know what's in your cupboard?"* (P2). The participants also highlighted that for the system to achieve it's goal, it requires the collaboration of all actors. *"For it to work, everybody needs to use it."* (P4).

4.3.3 Adaptation

Adaptive lifestyle. Participants wanted the system to be adaptive to their mood. Several mentioned how what they want for dinner can change at short notice and that they want the system to adapt to these changes. *"I struggle with the* *it's gonna tell you what you're gonna eat that night because I change my mind... I just fancy so and so and I don't want to plan what I want to eat."* (N6)

Social triggers. Participants in both groups acknowledged with software systems, users require a period of time to acclimatize to adaptive features. *"It's not far from Google knowing all about your browse and showing you advertisement about everything you ever do.... then it's your pulse, but it's a small extension"* (P4). A few mentioned that they would start using such a system once it was demonstrated to work correctly and a large section of the population began using the software. *"It would freak you out but if everyone has, then a year or two it becomes the normal thing to do, so then it wouldn't freak anyone out"* (P5) *"I'd be sat on the fence for a little while and if it worked I'd jump in."* (N2).

4.3.4 Personalisation

Control versus automation. Several of the participants did not like the idea that *Home Hub* would automate meal planing. Some cited *"spontaneity"* (P2) as a reason for reducing the automation of the system. One participant commented that there was something *"joyless about being told what you'd like"* (N1). Another remarked that it was *"intrusive... and was taking a lot personal responsibility away from you"* (P3)

Most participants agreed that a balance needed to be struck between how much control the user had versus how much automation was involved in the system. When presented with the idea that because of the biological sensors the user wears the system can suggest meals according to their mood, the viewers of the positive animation described this as *"scary"* (P1, P3). *"you can see what it wants to buy and then you can just click yes"* (P4) *"It's gonna suggest range of meals so you'll have the options to say I don't want that"* (P3)

During both sessions the issue of how much physical control the system would have arose. Some participants liked the idea that the system could put in place physical restrictions to help the user meet health and dietary goals. But they also expressed reservation about whether they would be happy with these restrictions once they were put in place. *"If I could tell it I'm on diet don't let me eat anything... can it shout at me you can't eat that or lock the cupboard, that would be good, I'll be happy... but in reality would you really"* (P3)

Time Investment. A number of participants were concerned with the initial time investment required to begin using the system. Their concern was that configuring a system like the one described in the videos would be time consuming; *"We often end up with off-the-shelf delivery that nobody has the time or inclination to change the options."* (N1)

5. A RESEARCH AGENDA

This paper has proposed an exemplar that highlights some of the current challenges for engineering adaptive software for the IoT, in particular: complex and emergent security and privacy requirements, interoperability of systems of systems, dynamic adaptation, and the interplay between digital, physical and social aspects. Building on this, we suggest some research directions to address these challenges.

Emergent collaborations. Ensuring the connectivity of devices, people, and their environment is not enough. One must ensure their seamless and meaningful collaboration. Collaboration between devices requires future-proof interoperability solutions that are not restricted to today's devices; that is, devices based on existing middleware and standards. *Emergent middleware* [5] might be the way forward. Emergent middleware is a dynamically synthesised software entity for the current operating environment and context, which makes devices interoperate seamlessly. To synthesise emergent middleware, one must be able to capture, represent, and reason about the capabilities of these devices and overcome their heterogeneity from applications down to the middleware and network layers. Involving human agents in these collaborations is even more challenging as human behaviour is difficult to model and analyse. The work of Cámara *et al.* [8] provides a formal model to represent and reason about human behaviour in order to develop adaptation strategies involving both human agents (acting as actuators only) and software components. Some parameters for this model (e.g., stress level) can be obtained using wearable sensors. Nevertheless, a richer model might be necessary to involve human agents as decision makers when implementing complex collaborations. Collaboration may also be used to improve security [6]. Collaborative security aims to dynamically deploy security controls according to the components available at runtime, thereby reacting rapidly to changes in the environment, changes in assets under protection and their values, and the discovery of new threats and vulnerabilities using the components already available.

Explained serendipity. Our preliminary study emphasised the diversity of people's expectations. Users want smart software systems that can understand, or even anticipate, their needs and desires, they want these systems to be able to cope with their mood swings/changes but they also want to be surprised. This emphasises the need for adaptive systems to empower users by (i) providing them with several options for adaptation to choose from, some of which are outside the usual operating envelop of the system, and (ii) explaining the reasons for certain adaptation strategies. For example, traceability links can be used to explain the rationale for some adaptations [25, 34].

Wisdom of the (social) group. Our study showed that many people are ready to give up some of their private data as long as there are enough incentives for them to do so. These incentives are often social. Social triggers might include that most people in their social networks' are also sharing their data. For example, the privacy settings of an individual may be influenced by the privacy settings of the members of the social or professional groups to which this individual belongs [7]. The incentives may also be political, as is the case with social activism [27]. Exploring social, as well as technical aspects during adaptation is in line with the agenda of the research community that emphasises the need to consider the cyber, physical, and social aspects when engineering adaptive software systems [30].

We believe that *Feed me, Feed me* captures many challenges for engineering adaptive software in the years ahead, and we invite other researchers to collaborate with us in extending and refining this exemplar as well as addressing these challenges and comparatively evaluating solutions.

Acknowledgments

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