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Abstract (for dissemination)	This document describes the overall architecture, individual components and sensors supported in the DIET4Elders monitoring infrastructure. Technology trends are described highlighting the relevance and future proofing of the design in relation to future commercial viability.

Dynamic nutrition bEhaviour awareness system FOR the Elders

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Deliverable **D2.1**
First version of the monitoring infrastructure and data representation

Restricted

VERSION HISTORY

Version	Edited by	Date	Description
0.1	TUC	03/11/2014	Table of Contents
0.2	TUNSTALL	10/12/2014	Added Monitoring and Infrastructure contents
0.3	TUNSTALL	16/12/2014	Changes based on internal review comments
0.4	TUC	18/12/2014	Reviewed document
0.5	TUNSTALL	18/12/2014	Incorporated review changes suggested by TUC
1.0	TUNSTALL	23/12/2014	Updated following final review

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1 Introduction

The urgency surrounding the increasing size of the ageing population is placing a tremendous burden on health and social services in many European countries. Enabling older adults to live independently at home is seen as one of the promising ways forward, perceived best for both the individuals as well as their carers. One of the critical issues affecting an older adult's ability to live independently at home can be unhealthy self-feeding behaviour which may lead to malnutrition [1].

The DIET4Elders (Dynamic nutrItion bEhaviour awareness sysTem FOR the Elders) project aims to create a system of support services to enable older adults to self-manage their nutritional intake, thus preventing unhealthy self-feeding habits and helping them to follow a healthy diet.

Following a healthy diet plan that meets an older adult's nutritional needs, whilst also considering their health profile and food preferences, is a challenging task and there are many factors which need to be considered. One such factor is that key health indicators must be considered to identify risks associated with malnutrition including changes in weight (or Body Mass Index (BMI)) and levels of physical activity. Whilst significant short term changes are important to observe, it is also essential to identify longer term changes in readings and behaviour patterns in order to understand any impact to an older adult's risk of malnutrition. To address these requirements the DIET4Elders solution includes the definition and development of smart sensors and associated monitoring infrastructure to unobtrusively collect environmental and activity data associated with an older adult and their residential setting. This infrastructure is capable of monitoring an individual in their place of residence, through environmental sensors, as well as determining activity levels outside the home utilising modern wearable activity tracker technology. Combined this will provide a reliable view on an individual's activity levels, helpful in determining appropriate levels of required nutrition.

In addition to activity levels, health vital signs are monitored in the residence through the use of wireless sensor devices. The initial focus will be on weight management, through the use of wireless weighing scales, although the monitoring infrastructure provides the scope to extend and incorporate other health vital signs monitoring (e.g. blood pressure, pulse, blood glucose etc.) as required. It is not however intended that the DIET4Elders system will provide a medically approved health monitoring service (as in a CE Marked Telehealth solution for example) or an emergency response services (as in Telecare).

Collection of data from sensors will be facilitated through the use of an advanced hub. This will act as both the mechanism to interact and gather sensor data, as well as provide the medium for user interaction around other qualitative data gathering or to provide end users with a direct view into their DIET4Elders system.

The main objective of the monitoring infrastructure is to gather and supply reliable and frequent data to the DIET4Elders Monitoring Database), such that it can be used to populate and instantiate the Nutrition Care Process ontology used in the decision support process for identifying nutrition problems and recommending interventions where necessary. As such, common and agreed data standards are used to represent the sensor data gathered. Similarly common interface standards are included to ensure the availability of sensor data when needed by the Support Services. For the purposes of DIET4Elders, sensor data will be made available in a “near real-time” context, where the focus is on allowing the system to respond to patterns inferred from data gathered over several days or weeks, rather than reacting to individual or critical events.

The remainder of this deliverable is organized as follows:

- Section 2 presents the intended scope of this deliverable;
- Section 3 details the design and development of the monitoring infrastructure including technology trends influencing the design decisions and proposed technical implementation;
- Section 4 provides the deliverable conclusions.

2 Scope

The scope of this deliverable is to provide a first draft of the planned monitoring infrastructure required for the DIET4Elders solution. This includes describing an integrated monitoring infrastructure for collecting the relevant data associated with an older adult's self-feeding activities, the sensors required to gather the necessary data and the means by which this data will be integrated into the overall DIET4Elders solution.

The approach described is based on a number of key inputs including:

- an analysis of the user needs, as described within deliverable D2.0 End-users Scenarios Analysis & Requirements;
- definition of requirements from Nutritionist professionals as described by our experts within Kings College in deliverable D3.1;
- evaluation of current technology trends within the sector;
- evaluation of market needs and commercial opportunities provided in deliverable D6.1;
- Tunstall's experience designing and delivering technology enabled care services to over 3 million older adults worldwide.

This deliverable forms part of Work Package 2 and is a specific outcome of task 2.2. As part of the overall work plan, it is expected that this draft will be refined following user feedback from the pilot and field trials as described within Work Package 5.

In parallel, the related work on D6.1 the first draft of the business and exploitation plan has been incorporated, but it is anticipated that as commercial propositions are further developed the monitoring infrastructure will adapt to reflect any changes in the market needs, emerging commercial opportunities and end user expectations.

3 Monitoring Infrastructure Design and Development

Following a healthy diet plan that meets an older adult's nutritional needs, while accommodating their medical conditions and activity levels, is essential for addressing problems associated with malnutrition. Whilst those living on their own may wish (and are encouraged) to remain independent, their ability to balance their nutritional intake with their activity levels, knowing how much of different types of food to consume may be affected by various aging-related diseases, making it difficult for them to maintain a well-balanced diet.

The use of unobtrusive sensors to gather health related data, such as their weight and activity levels, provides reliable, regular and consistent data for nutritionist professionals to assess their needs more accurately. In addition, it provides an opportunity for such older adults to understand their situation more directly, appreciating the importance of eating a healthy diet and the effect it can have on their health.

Based on the defined user requirements and specialist nutritional input the relevant sensor monitoring needs have been identified. These cover the needs to be able to monitor two key aspects of an older adult's lifestyle, namely:

- Activity levels - both inside and outside the home;
- Vital signs readings – focused initially on weight in order to calculate changes in Body Mass Index (BMI).

Whilst the broader user requirements identify an array of different sensor data required, these are primarily associated with compliance activities, for example the knowledge that a fridge or microwave have not been opened or used might imply a home-cooked meal has been missed. Our Nutritionist colleagues concluded that in order to effectively identify changed risk of malnutrition, sensors would be required to regularly capture a person's weight and their levels of activity, both inside and outside the home.

Capturing weight is a common application within Telehealth programmes, typically performed through the use of wireless weighing scales in the individual's home and transmission of this data to a central monitoring infrastructure. The latter requirement on activity tracking is less common in older adults but suggests the need for technologies more commonly associated with health and fitness tracking such as wearable, personalized sensors used to track simple activity measures such as number of steps taken or distance travelled.

Consequently as part of the monitoring infrastructure considerations a review of applicable technology and market trends was undertaken to ensure any designs were future-proofed.

3.1 Technology Trends

There are many technology trends that could be considered as having some predicted impact on the DIET4Elders solution, however we have focussed on five specific areas identified as having significant potential impact on the design of the DIET4Elders monitoring infrastructure. These are:

1. Health and Wellness activity monitoring;
2. Wearables;
3. Internet of Things/Internet of Everything;
4. Smart Homes;
5. Health Apps.

Each is discussed further in this section.

3.1.1 Health and Wellness Activity Monitoring

The current market for health and wellness sensors which track activity levels is in a state of maturing. Despite some products, such as the Nike+, being around since 2006, consumer adoption has been limited, focusing mainly on the general consumer fitness markets. Historically, these activity sensors have typically depended on pairing with a smartphone and smartphone apps, meaning that adoption has been mainly restricted to the smartphone user community, and consequently quite limited adoption within the typical DIET4Elders end user community. It is expected that the arrival of large consumer manufacturers such as Apple, Samsung and soon to be Microsoft will begin to merge these devices into the more general wearables market as mainstream electronic devices, providing consumers with more choice and driving down prices.

3.1.2 Wearables

Both Gartner [2] and International Data Corporation (IDC) [3] identify wearable technology as having significant technological impact in their future technology predictions, even if for IDC they believe this may not translate immediately into real market value growth. However it is clear from Figure 1 below that the growth in the wearable devices market has been significant in the last 12 months, in several European countries including Germany, UK, Spain and The Netherlands overall retail sales revenues have been shown to more than double. This can only be expected to increase with the arrival of new consumer-oriented products from well-established consumer electronics manufacturers such as Apple, Samsung and Microsoft with their extensive existing customer bases.

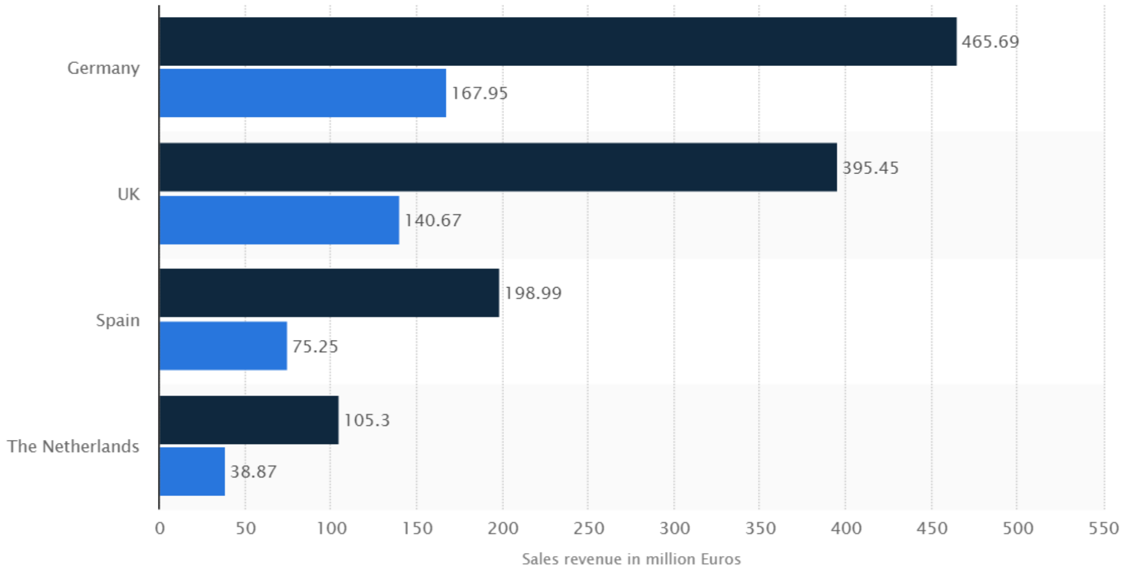

Figure 1: Sales revenue at retail of wearables in selected European countries in 2013 and 2014 (in million Euros)

Source: http://www.statista.com/statistics/375909/wearables-sales-revenue-by-european-countries/

IDC, in their FutureScape: Worldwide Internet of Things 2015 Prediction [4] forecast that within five years, 40% of wearables will have evolved into a viable consumer mass market alternative to smartphones.

Wikipedia describes wearable technology as “clothing and accessories incorporating computer and advanced electronic technologies”. Real applications of this technology include the growing numbers of smartwatches, smartbands/activity trackers and some more aesthetic items fashioned as jewellery. For example in 2014 Ralph Lauren tested smart wearable shirts on ballboys at the US Open Tennis Championships to track activity levels, breathing and heart rate, with data transmitted wirelessly via a smartphone [5]. Wearable technology however exists in much broader contexts and in its 2013 evaluation of Google

Glass, as part of its North American Technographics Consumer Technology Survey [6] Forrester identified a variety of different wearable form factors available, as illustrated below in Figure 2 **Error! Reference source not found.**. From a market perspective this research shows a market in broad development with many opportunities likely to continue to emerge.

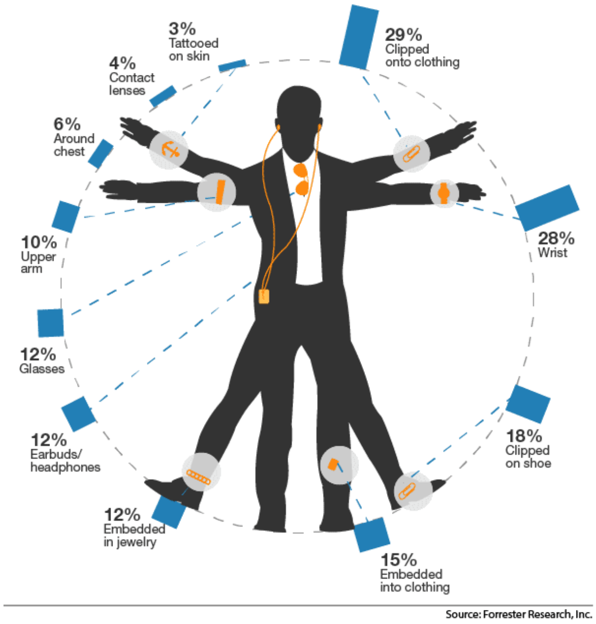

Figure 2: Wearable computing form factors - Forrester

3.1.3 Internet of Things (IoT)/Internet of Everything (IoE)

IoT is gaining considerable newspaper column inches following successive International Consumer Electronics Shows (CES®) and other related consumer electronics events. This is the concept of a wide variety of devices and sensors being able to gather data and connect to the Internet to make this data available for use in a connected or integrated way. For example this could be a washing machine gathering data about usage and service requirements for remote monitoring by the manufacturer or Service Company, or a bed capable of tracking sleep patterns through embedded sensors and sending the results to your smartphone or tablet.

Gartner [7] predict that by 2020 there will be nearly 25 billion connected “things” in use and contributing to IoT, with 4.9 billion predicted to be in use in 2015. This translates to a predicted total services spending of $69.5 billion in 2015 and $263 billion by 2020.

Much of the growth is predicted to derive from consumer devices where it is estimated there will be over 13 billion connected things by 2020. As a consequence technology companies are investing heavily in the platforms and infrastructure needed to cope with and drive adoption of these technologies.

These are significant trend predictions and undoubtedly will have an impact on the technologies used across many demographic groups, including those potentially targeted as future buyers and end users of the DIETElders service.

3.1.4 Smart Homes

A term commonly linked to IoT is "smart". *Smart*phones, *smart* cities and *smart* homes illustrate this term to imply the application of IoT concepts and technology to create more connected entities. Smart homes refers to a specific application of IoT relating to a person's residence and the use of technologies to assist with home automation and monitoring.

There are specific initiatives in particular in European countries looking to allow people to monitor and manage their homes in a more automated way. An example being some of the energy efficiency initiatives in the UK, where national utility companies have already installed more than 1.5 million smart meters into homes and offices [8]. By 2020 the UK Government plans for every home and business to have such a meter (nearly 50 million [8]) allowing users to see when they are using energy and how much it costs.

Other smart technologies are also becoming mainstream consumer devices. According to results from Informa Telecoms and Media research [9], shown in Figure 3 below, in less than three years the install base of connected-TV devices has increased fourfold to nearly 500 million, with a more than 1.8 billion connected TV devices predicted in the home by 2016.

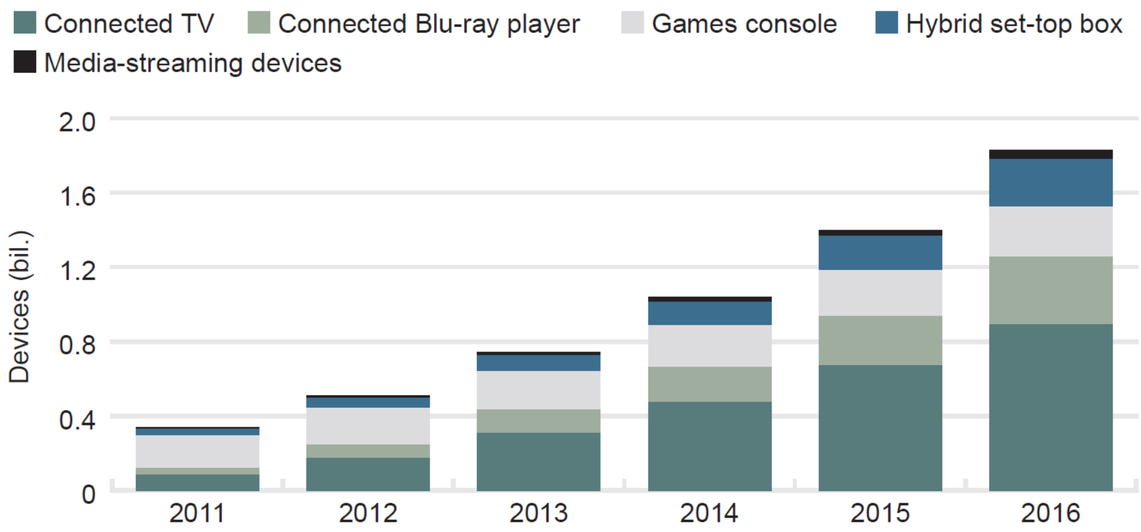

Figure 3: Global installed base of connected-TV devices 2011-2016 source: Informa Telecoms & Media

Such Smart and connected homes present a growing opportunity for future technology solutions.

3.1.5 Health Apps

One of the more recent trends, specifically around the application of some of the earlier mentioned technology trends in the healthcare sector has been mobile health apps. Whilst the apps themselves are generally covered under the concepts of Health and Wellness Activity Monitoring and/or wearables, the trend observed is more to do with governance and quality. In 2013, The U.S. Food and Drug Administration (FDA) issued specific guidance around medical applications [10], as did the Medicines and Healthcare Products Regulatory Agency (MHRA) in the UK [11]. The purpose in each case being to clarify the distinction between health apps and medical devices, in particular due to the heavily regulated world of medical devices. These clarifications have allowed health app developers to understand how their products will be interpreted by Health Regulatory Bodies such as FDA or MHRA, and where appropriate address the significance costs associated with developing and maintaining medical devices.

Whilst reliable data is in short supply about the number of health apps available on the Apple and Android app stores, the number of health apps is clearly continuing to grow. Some studies suggest that mobile health applications and the services that go with them generated revenues of $2.4 billion in 2013 and could grow to $26 billion by the end of 2017 [12], with predictions that more than 500 million smartphone users will be using a healthcare application by 2015.

In addition, traditional models of healthcare delivery are beginning to adopt health app models, for example, the UK government is already working on plans to approve health apps for prescription under a kite mark scheme available through the publicly funded National Health Service [13].

3.2 DIET4Elders Monitoring Infrastructure

For the purposes of DIET4Elders there is a clear need identified to track an individual's activity levels in order to determine an appropriate calorie intake level. When considering potential end users of the system, our user scenarios identified some typical situations where individuals would still be active, leaving their homes to perhaps shop locally for food or stay involved in local activities. For this reason a collection of sensors bound physically to the home would be insufficient to track an individual's activity levels. Typical in-home sensors consist of devices to track specific activities such as opening a door, moving between rooms or switching on a kettle. In isolation these sensors provide limited value but when combined and monitored over a period of time, they can lead to patterns of individual behaviour being deduced and more importantly when those patterns change.

The monitoring infrastructure is envisioned to be developed and deployed in two incremental phases, namely:

- Core Activity Monitoring (CAM);
- Sensor System Infrastructure (SSI).

CAM consists of the deployment of three essential components of the monitoring infrastructure including a digital communications hub, weighing scales and activity tracker device.

SSI extends the CAM platform by adding Tunstall's next generation digital care hub and a number of environmental sensors associated with an individual's residence. This additional sensors or peripherals include sensors to allow the tracking of specific activity such as opening/closing a door (fridge or entry door to a residence), using an electrical device such as a microwave or kettle, sitting in a favourite chair, moving around a residence, etc. On their own, the information from these sensors has a limited use, but once combined with data from the CAM infrastructure, can infer a variety of activities that have been undertaken.

The next sections discuss the two phases of the monitoring infrastructure in more detail, describing the technologies used and planned architectural design of system interactions.

3.2.1 Core Activity Monitoring

The design for the CAM infrastructure is depicted below in Figure 4 below. The anticipated main user scenario for this infrastructure consists of the older adult utilising a standard commercial off the shelf (COTS) tablet device (Android or iOS) to run a general health application, which is connected wirelessly to initially two health sensors: a set of weighing scales and fitness activity monitor.

Figure 4: Core Activity Monitoring (CAM) Infrastructure design

Typically health sensors have been used to track patients with defined long term conditions, such as diabetes or heart-related conditions, but applications are changing. In particular where more consumer-oriented wearable sensors have entered the marketplace and with the rapid growth of app-based health monitoring via smartphones.

The CAM health application provides the means to gather and interpret data from a set of weighing scales (communicating over wireless Bluetooth Low Energy (BTLE)), as well as combine this information with data gathered through a wrist-worn COTS activity monitoring bracelet. Whilst the health application will provide interfaces to the user to observe and track this data, this will not be its primary purpose within DIET4Elders. Instead it will initially act as the proxy to ensure the necessary health data can be gathered wirelessly from the appropriate sensors, transmitted securely to a cloud-based repository (Cloud Data Services) and integrated with activity data gathered via a commercially available service such as Fitbit [14] for example.

The CAM infrastructure platform is designed to be flexible and modular, in that new additional sensors can be added and connected to the system without disruption or significant change to the platform. As such, this platform will form the basis of the first prototype and will be influenced by subsequent user testing during pilot stage.

Data is generated by the health and activity sensors based on user activity, for example the user is required to wear the fitness activity monitor or step on the weighing scales in order to generate data readings. However the user is not required to action the transfer of the associated data within the health application.

3.2.2 Sensor System Infrastructure

The SSI platform will be a natural evolution of the CAM infrastructure, by extending the sensor capabilities and incorporating infrastructure which does not depend on the utilization of a COTS tablet. This will allow the addition of a number of environmental sensors, providing further monitoring information about an individual in their own residence. This technology is not intended to be used in group settings, for example in care facilities, although it is applicable for use within multi-resident settings i.e. where two or more people live together.

The main components of SSI extend the CAM infrastructure with the inclusion of Tunstall's environmental sensors and next generation digital hub. These are shown in Figure 5 overleaf.

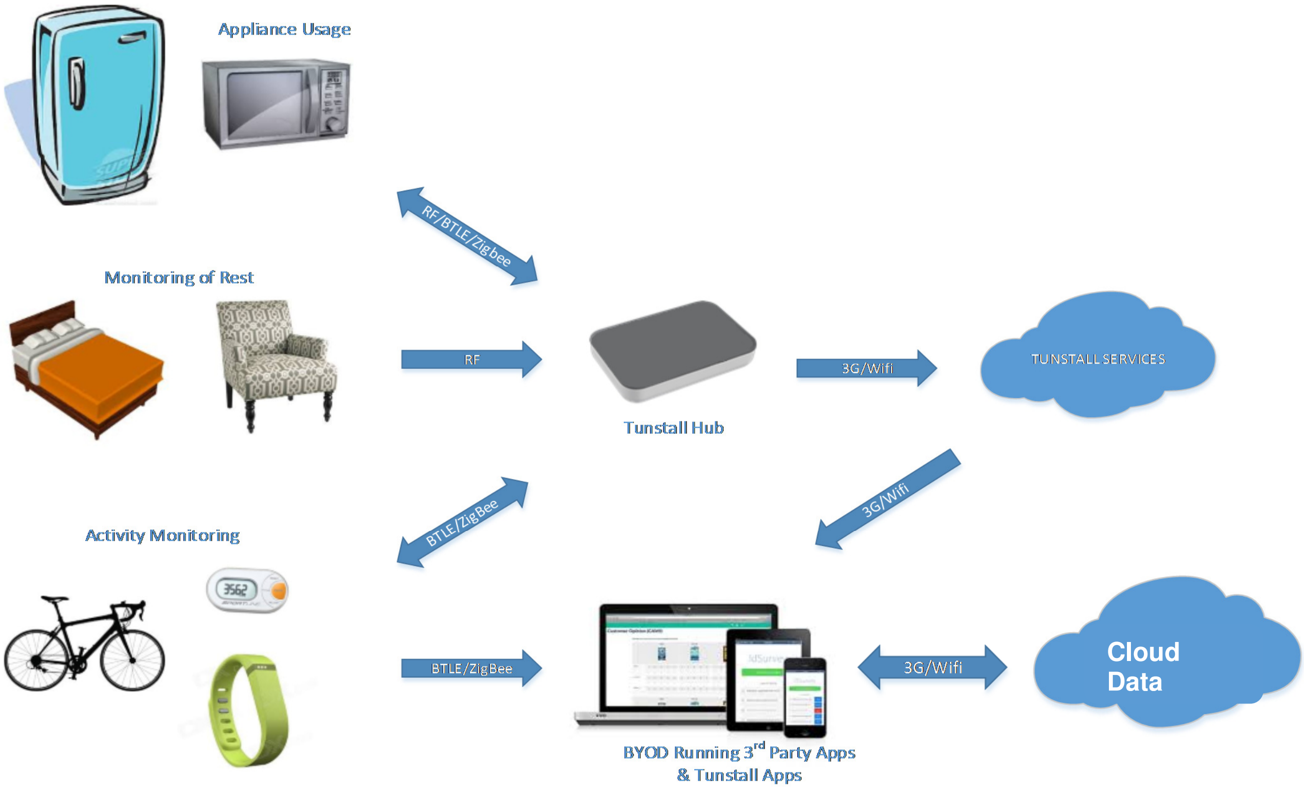

Figure 5: Sensor System Infrastructure

SSI incorporates the CAM platform and extends it in several ways.

Firstly through additional health sensors, by allowing the connection of a variety of other health and activity monitoring devices, including for example devices for measuring blood pressure, blood glucose and pulse rates. These will be added to communicate through the health application running on the tablet device.

Secondly SSI will include the incorporation of Tunstall's digital communications hub and wireless environmental sensors. The Tunstall hub is designed to be flexible and scalable, capable of receiving and in some cases interpreting the events generated by the environment al sensors when active, which is discussed in more detail in later sections. Initially its purpose within DIET4Elders is to support the connection of environmental sensors easily and independently of existing sensors, whilst allowing for the integration of environmental sensor and health and activity sensor events, within a single platform. Environmental sensors tend to be simple devices, capable only of triggering a limited number of events. In many cases these will be limited to simple ‘on/off’ type events; however they can sometimes be combined and interpreted to represent more complex meanings.

In the first instance the Tunstall digital hub will support the use of four environmental sensors, namely:

- Chair occupancy pressure sensor – this sensor would typically be placed under a cushion on a favourite chair. An event is triggered whenever an individual gets up from a chair and can therefore be used to identify those who may spend lengthy periods seated (see Figure 6).

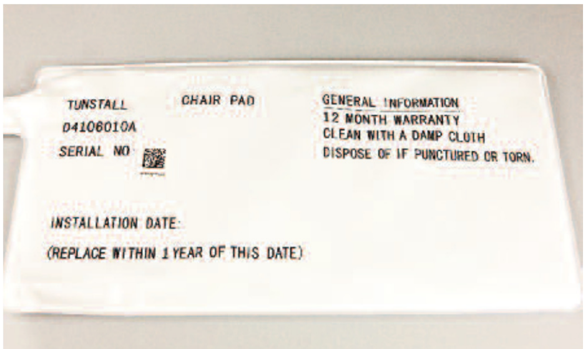

Figure 6: Chair occupancy sensor

- Door/Contact sensor – this sensor can be attached to doors in the home or on devices such as a fridge to detect when a door is opened. An event is triggered when a door is opened, indicating for example when an individual has opened a fridge (see Figure 7).

Figure 7: Door/Contact sensor

- Electrical Usage sensor - this sensor is designed to detect when a connected electrical appliance is switched on/off (see Figure 8). For example in the case of a user heating a pre-prepared meal in a microwave, this sensor could detect when a microwave has been activated and used. This is not the same as identifying that a specific meal has been heated or consumed, however what is perhaps of more significance is when this event is not triggered i.e. it can be an indicator on inactivity when a user has not used the microwave.

Figure 8: Electrical Usage sensor

- Motion Detection sensors - these sensors, also known as Passive Infra Red Sensors (or PIRs) are wireless movement detectors that can be used to detect both movement and lack of movement (inactivity monitoring) (see Figure 9). They are typically placed around a residence in appropriate locations such that movement patterns can be determined. In this way changes over time can be detected, for example if a person become less mobile over time they may move around their residence far less.

Figure 9: Motion Detection sensor

As an example of the interactions involved in one such environmental sensor generating events, let us consider the situation where a user has a Chair Occupancy Sensor fitted in their home (see Figure 10).

Figure10: Environmental Sensor Example

i. Here a person sits in the chair activating the chair pressure sensor.
ii. The chair pressure sensor transmits an event to the Tunstall Hub
iii. The Tunstall Hub collects either a single or multiple events and transmits the data to a Tunstall server via an IP connection.
iv. 3rd party systems (including other Cloud-based Data Services) with the correct authorisation can then retrieve this data (via RESTful API) and then generate analytical reports.

3.2.3 Tunstall Digital Hub

The Tunstall Digital Hub (or Tunstall Hub) acts as the primary conduit for receiving and transferring environmental sensor events from sensor to Tunstall Services, Tunstall's Cloud-based Data Services based on Azure Service Bus. In this case sensors which are triggered, as a result of physical or automated activation, generate an event. This event is communicated wirelessly to the Tunstall Hub and stored before transmitting the data to the Tunstall Services, via a wired or cellular digital connection. The Tunstall Hub provides the means to store a batch of events and transmit them collectively, if required, as well as the means to configure and optionally interpret the events received from the sensor before transmission onwards. At present the Tunstall Hub is based on a future evolution of Tunstall's existing Lifeline Vi device, called the Lifeline Vi IP (see http://uk.tunstall.com/solutions/lifeline-vi for more details).

The Tunstall Hub is a TeleCare home unit that communicates with sensors and relays an event to an Alarm Response Centre (ARC) and a cloud-based service such as Tunstall Services, as shown in Figure below. Within the Tunstall Hub, configuration can determine which events are published and in some cases limit the frequency of the upload.

Figure 11: Tunstall Hub Event Model

When the system is installed, the installer will connect the environmental sensors to the Tunstall Hub either by a wired connection or wirelessly. Within the Tunstall Hub's configuration, each environmental sensor is uniquely identified and provided with a textual description e.g. Electrical usage - microwave. In the event of a sensor triggering, the Tunstall hub is informed and analyses the data to decide what action to take. Typically this action could be either to:

- generate a call to ARC;
- publish the event for distribution.

For example, in the case of an electrical usage event, data would be captured by the Tunstall Hub and as this is unlikely to be a critical activity the data will be stored and then published to the Tunstall Services for storage. In some cases both types of output could be generated, for example a LifeLine Hub could be configured to interpret a typical door activation as a critical event if it occurs during the timeframe 11pm to 6am.

It is likely that most events generated by the environment sensors in DIET4Elders will be classed as non-critical and stored by the Tunstall Hub before being forwarded to the Tunstall Services.

No user interaction will be involved or required as part of the capturing, interpretation and transmission of environmental sensor event data.

3.2.4 Tunstall Cloud Data Services

The Tunstall Cloud Data Services (or Tunstall Services) will provide the persistence mechanism for storing event data generated by the environmental sensors and transmitted by the Tunstall Hub. Data will be held securely and anonymously, with access to this data provided only to trusted and authorized services and applications.

This will consist of a Microsoft Azure cloud hosted Service Bus, from which data is published to an endpoint such as into a hosted Microsoft SQL Server database for any post processing analysis.

In production the customer will have a choice of a number of cloud messaging services through which they can receive notification of events. Which service to use and the endpoint path will be configurable on the Tunstall Hub on a per customer basis. For the initial communication the Tunstall Hub will publish its messages to a Topic in Microsoft Azure Service Bus.

Microsoft Azure Service Bus provides connectivity from any programming language that supports REST over HTTP/s and has additional functionality for .Net based languages.

In some circumstances it will be desirable to store events from the Tunstall Hub to a data store such as a relational database. The system will contain one such service that will subscribe to the event Topic and will push each event to a data store so that it can be persisted and included in analysis. Furthermore this would allow for the integration of data between environmental sensors and health and activity sensors, in a preferred Cloud Data Service or as an extension of the Azure-based Tunstall Service.

3.2.5 Communication Message Format

A BrokeredMessage object will be published to the Topic. The BrokeredMessage.Body property will contain a THCEvent object serialised as JavaScript Object Notation (JSON).

3.2.6 Event Model

The event published from the Tunstall Hub is described through a THCEvent object which will have a structure as shown in figure 12.

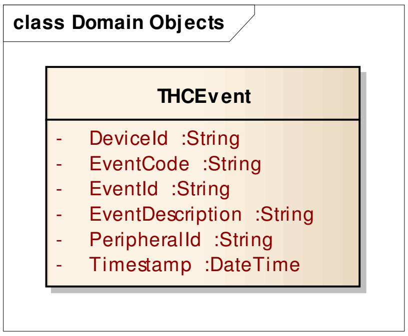

Figure 12: Event Model

The structure of the attributes associated with THCEvent are described in more detail in Table 1 below.

Table 1: Detail of THCEvent Structure

Field	Description
EventId	A unique identifier for this event. A string representation of a Globally Unique Identifier (GUID).
EventCode	A code or other data that provides detail associated with the event.

EventDescription	A textual description of the event indicating the type of peripheral and its location in the dwelling.
DeviceId	A unique identifier for the associated Tunstall Hub.
PeripheralId	Identifies a specific peripheral associated with the device in the case that the event is raised by a peripheral.
Timestamp	The date and time that the event was raised. Uses the date/time held by the device.

The event will be published from the Tunstall Hub in JSON format to promote interoperability. Similarly the event will be published from Azure Service Bus in JSON format. An example of the serialized event format is shown below:


```
{
 "Timestamp": "2014-12-09T09:59:46.0823476Z",
 "Id": "65729611-0246-45a9-86e2-40242d2153d4",
 "DeviceId": "4aca747c-e958-4c7d-98e7-d4c24eedaf27",
 "EventCode": "0x0001EBAC",
 "PeripheralId": "100012",
 "EventDescription": "Front Door Opened."
}
```


3.2.7 Future Connectivity Options

The architecture of the proposed DIET4Elders Monitoring Infrastructure is intended to be flexible and accommodate opportunities to utilize different available connectivity options. The design is being considered such that if commercial propositions determine that IP connectivity is not widely available within a deployed location or is too costly, then connectivity could be shared between the Tunstall Hub and the COTS tablet. For example the Tunstall Hub could transfer its event data to the Tunstall Services utilizing an existing cellular connection available through the COTS tablet device. The viability of this capability will be determined as part of the next phase in development of the monitoring infrastructure.

Similarly the extension of standard APIs offered by commercial cloud providers and supported by the initial Azure implementation, will facilitate flexibility when it comes to consideration and costs of the deployment of any future commercial proposition, allowing different commercial hosting or cloud providers to be considered.

4 Conclusions

The DIET4Elders monitoring infrastructure should account for the growing trends of wearable devices (fitness and activity tracking) and the predicted significance of Internet of Things platforms and devices. As such a modular and extendable design is required to ensure maximum potential for commercial exploitation.

Two types of sensors are required to track DIET4Elders users: health and activity sensors, and environmental sensors.

Healthy and activity sensors include sensors to track a person's health vital signs, such as their weight or blood pressure, as well monitoring their activity levels, such as the number of steps taken or distance walked.

Environmental sensors include sensors that are deployed into and track activity within a user's home. They are non-intrusive but allow for the gathering of useful events about activity performed in the home such as use of a microwave, opening of a fridge or movement between rooms or outside.

Sensor data is gathered as a series of events and transmitted digitally by a Tunstall Hub, via an existing broadband connection in the individual's home or through a cellular connection.

All sensor data would be generated with minimal user involvement – only health sensors, such as weighing scales or blood pressure monitors for example, would require user intervention.

All data would be held securely and anonymously via a cloud-based dataservices, Tunstall Services, with access provided through standards-based APIs to authorized applications and services only.

The next stage of this deliverable will be the final version delivered in June 2016. This will include updates to the monitoring infrastructure design reflecting practical implementation issues encountered and feedback from user pilot and trials. It will also include feedback from activities planned in 2015/16 for the broader rollout of the Tunstall

Hub and associated cloud services, along with implications identified as part of the business plan development and testing of commercial propositions in the markets.

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