



HAT Personal Data Exchange Ecosystem: Technology Architecture Briefing Paper 4



RCUK Digital Economy HAT Project
<http://hubofallthings.org>
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HAT Personal Data Exchange Ecosystem: Technology Architecture

The HAT Project¹ is a £1.2m multi-disciplinary research project funded by the Research Councils UK (RCUK), led by Irene Ng at WMG, University of Warwick with 6 other professors from Cambridge, UWE, Surrey, Edinburgh, Nottingham and Warwick University's Economics department. The project set out to engineer a market for personal data and therefore design the economic and business models relevant for this market. Over the course of the research, the HAT Project team has done some substantial work to emerge a solution: The HAT personal data ecosystem, a multi-sided market platform for personal data exchanges by way of a personal data store that takes data from connected services and devices, powered by the Internet of Things (IoT).

This briefing paper contains a high-level description of the (personal) HAT technical architecture. Building upon the assumption that the adoption of the HAT technology will form the basis of the personal data exchange, we also propose a personal data exchange ecosystem architecture.

1. Overview

All of us “haemorrhage” personal information (data) to our service providers (the businesses who harvest our data) – through the “web” – to the point that we have lost control of our data and get almost no real value from it from these businesses that sell us goods and services or from the emerging “sharing economy”. It is time for us to regain control of our personal data and put ourselves, as individuals, at the centre of the growing data exchange in the sharing economy. But as individuals we cannot effectively broker, or exchange or monetise our data because we cannot integrate data across the vertical repositories – between for example, our diary, messages, location, finances or consumption – and integrate this with applicable service timetables or catalogues. Nor can firms and other organisations really understand our needs to tailor personalised product or service offerings without being able to understand the context of our consumption.

¹ Find out more about the HAT project at <http://hubofallthings.com> which features a video introduction

As individuals, we may however need to be prepared to allow access to some of these contexts where it is likely to result in better offers. To do this, individuals need to be able collect, contextualise and bundle our personal data, and using suitable permissions, exchange our data with others, be they other individuals or organisations, within a trust-based framework. Equally, the commercial **organisations** involved need to have the same technology in place to exchange information – to receive and process personal data from individuals who have given their consent to these organisations, and who in turn could potentially share their own proprietary information with the individuals. This process could potentially provide the individual with truly personalised offerings. This is what the HAT platform does in order to enable a multi-sided market for connected services and products in the emerging personal data exchange ecosystem.

2. The HAT and its Personal Data Exchange Ecosystem

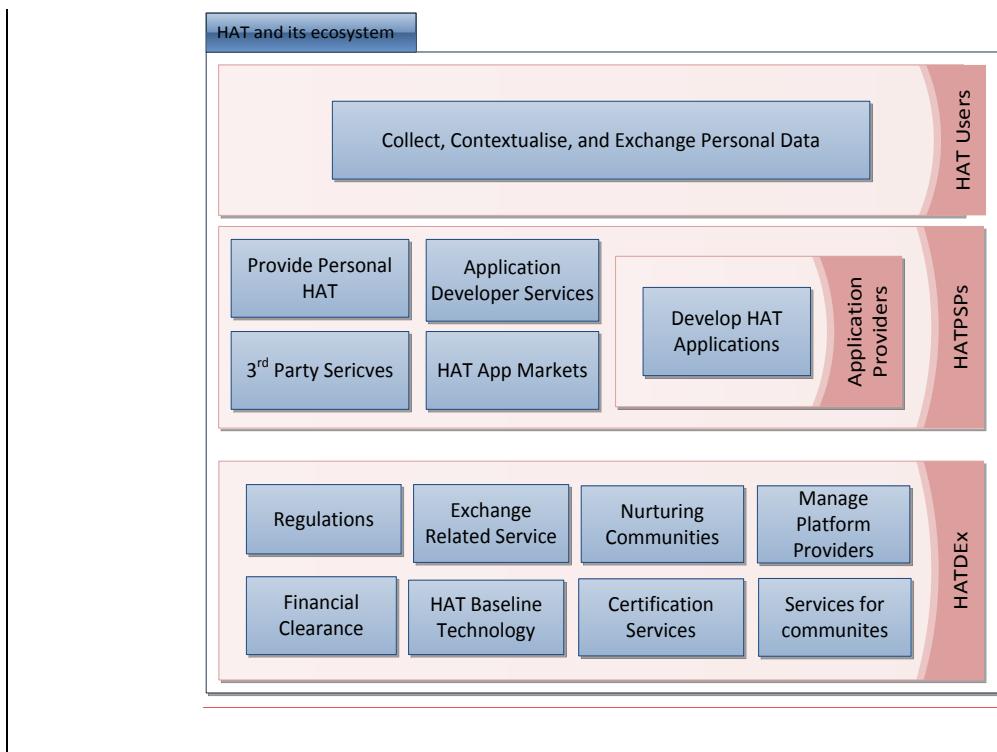
Technically, the HAT consists of a database schema, a data logic layer and APIs that allow individuals to flatten, contextualise, bundle and exchange all types of personal data. All this exists within a trust framework, hence allowing permitted exchange with other individuals or any “HAT-enabled” organisation with whom we wish to trade or exchange.

The HAT personal data exchange ecosystem can be understood as a three-tiered ecosystem, as it combines all the parties involved:

1. At the foundational level is the HAT regulatory system with a baseline technology for interoperability and exchange mechanisms; the **HATDeX** (HAT Data Exchange).
2. The next level is the service level comprising the **HAT Personal Data Platform Providers (HPPs)** along with **HAT Application Providers (HAPs)** who offer hosting services and other applications for Personal HATs.
3. The top/core level is the global HAT User level with their **Personal HAT server** (technically the HAT Personal Data Platform or **HATPDP**).

A diagram of the architecture is illustrated below. In the next section, we will describe each level of the ecosystem, beginning with the top (HAT user level) and how the activities are operationalised.

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2. 1 HAT User Level

The HAT and its personal data ecosystem are designed to allow individual HAT Users to collect, contextualise and exchange our personal data. The enabling technology for the HAT sits within the HATPDP, (mostly referred to as "HAT"). The Personal HAT is a person-oriented personal data platform, owned by the individuals, that allows us to unpick the silos in which our personal data sits and to collect all this data which we can acquire from internet-connected objects or services. The HAT then allows the transformation of this acquired data for individuals to **contextualise and organise**, to make it meaningful and useful for control decisions and actions. With that data, individuals can buy apps to analyse, view, create scenarios, trade or make important decisions based on our own data for a smarter and more effective life. The HAT is therefore a fully scalable platform that allows firms to offer individuals services for our personal data, and yet enables us as individuals to personalise that data to our own needs.

A HAT can be described as being analogous to an email account. As an individual HAT User, we can choose our HAT provider (also known as HPP in the HAT ecosystem) just like we choose our email account provider, and we can switch HPPs as there may be many such

providers. Or, if you want to host your own HAT, your Personal HAT can be configured to sit on your private server. In essence, individual HAT Users get to decide where we want our HAT, how to access our HAT and how to organise our HAT.

The HAT may be hosted in three different ways (depending on the providers). There are several types of Personal HATs:

1. **Hard Hat:** A HAT that is a fixed server with a fixed IP address, for example a smart home hub for home sensors. Likely to be on the HAT User's LAN network
2. **Sun Hat:** A HAT that is cloud-based. The Sun HAT is expected to be the most popular Personal HAT model, where every HAT potentially sits on a micro-cloud server owned by the individuals and hosted by HPPs. For example, Virtual Machine-based cloud servers operated in data centres.
3. **Straw Hat:** A hybrid of fixed and cloud-based HAT. E.g. some HAT data will be stored in a home hub, while other data will be stored in a cloud servicer. A straw HAT can also be a HAT that accesses personal data (without the need to store it) from distributed networks and where personal data can sit at the source of where it was generated (Note: Straw HAT will not be part of the initial release)

Technically, by signing up for a HAT with a HPP, you will be provided with:

1. A Globally Unique Identifier (GUID) to serve as the identification for a particular HAT in the ecosystem. A GUID in a HAT may take a DNS (domain name service) type approach; for example, Alice's HAT may be certified as alice.user.hubofallthings.com. This naming convention is designed for all parties in the ecosystem, e.g. paula.dev.noggin.com for a developer Paula, noggin.psp.hubofallthings.com and enableid.psp.hubofallthings.com for HPPs Noggin and Enable iD respectively.
2. A HAT Database built on the HAT Database Schema. Depends on the chosen HPP; the actual database engine may differ as long as the HAT Database Schema is followed. The HAT Database schema (currently at alpha stage) is issued under the Creative Commons Attribution-NoDerivatives 4.0 International (<http://creativecommons.org/licenses/by-nd/4.0/>). Future schema (beyond beta

- version) will be released under Creative Commons Attribution-ShareAlike 4.0 International (<http://creativecommons.org/licenses/by-sa/4.0/>)*
3. APIs to access your data (Input and Output) for other parties, as well as "Management" level APIs for the individuals (Input, Output and Management)
 4. A Hyper Data Browser, where you can see your data in your HAT, delete or move your HAT to a different HPP.

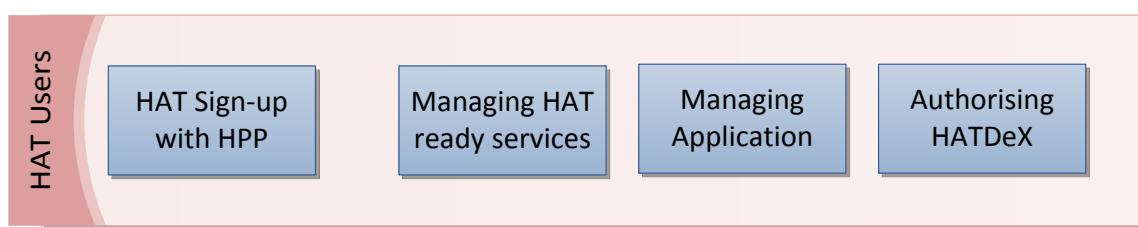
2.1.1 How data is collected in the HAT

As a user, once we have signed up for a HAT, we can place our data into it either by manually entering our data into our HATs, or by installing **HAT-Ready Services**² to automatically collect our personal data from various internet-connected devices or applications. This could be any sort of personal data we would like to place into our HATs; vital statistics such as height and weight, the number of steps we took today, our water usage in the shower, or what we bought when shopping at the local supermarket. Such data may be collected from many different internet-connected devices such as a pedometer on a piece of wearable technology or smart scales in the home, or from the databases of store loyalty cards or online calendars. Such sources of personal data can become HAT-Ready as long as such sources have an open API. For example, the alpha HAT release in Nov 2015 will allow users to pull their data into their HATs using **HAT-Ready Services** that include Facebook, Google Calendar, Fibaro Home Systems, Cube Sensors, Withing and Fitbit.

² HAT-Ready Services are a group of middleware applications operating between the HAT inbound API and other device/data outputs, to pull existing data from various industry verticals into the HAT Database. When the data arrives in the HAT, they will go through the HAT Data Logic Layer to be flattened (to a key-value alike structure). This is where the HAT will transform the verticals' industry-specific schemas into a user-oriented environment and life data structure for further "human touch" – the contextualisation.

2.1.2. How data is contextualised

Once our personal data is collected in our HATs, we can then contextualise the data. Currently, all data is collected and belong to device/service providers, who do not necessarily know the wider context of why such data has been generated, what else is related, and how they may be related. The only person who understands the contextualisation of our own data – the way we live our lives – is ourselves, the individual users. The HAT enables us to transform previously collected data into **Thing** (What), **Person** (Who), **Location** (Where), and **Event** (When), so that we can describe How we live – When and Where an event took place, What things and data are involved with Who (and potentially Why) by putting them (Who/When/Where/What) into a **Bundle**.



HAT users' roles in the Ecosystem

The user can organise HAT vertical data using the HAT interface to create People, Locations, Events and Things and their properties. **Personal Information** is one of the data collections most personal to the user and able to reuse data from a multitude of **HAT-Ready Services**, therefore it is included among the proposed **Collections**, which for example suggest that a person should have the properties of “First Name”, “Last Name”, various education and employment information, etc (see diagram on next page).

The screenshot shows the HAT Hyperdata Browser interface. On the left, there's a sidebar with a tree view of collections:

- Collections
 - Me
 - Personal info
 - Finance
 - Wardrobe
 - Books
 - Music
 - Home
 - Preferences
 - Locations
 - Home
 - Work
 - GP
 - Local
 - Now
 - [+] New
 - Contacts
 - [+] New
 - Family
 - Boon C Ho
 - Personal info
 - Preferences
 - Locations
 - Home
 - Work
 - GP
 - Now
 - [+] New
 - Friends
 - [+] New
 - [+] New

On the right, the main area displays the 'Collection Name: Personal information' details:

Collection Name: Personal information

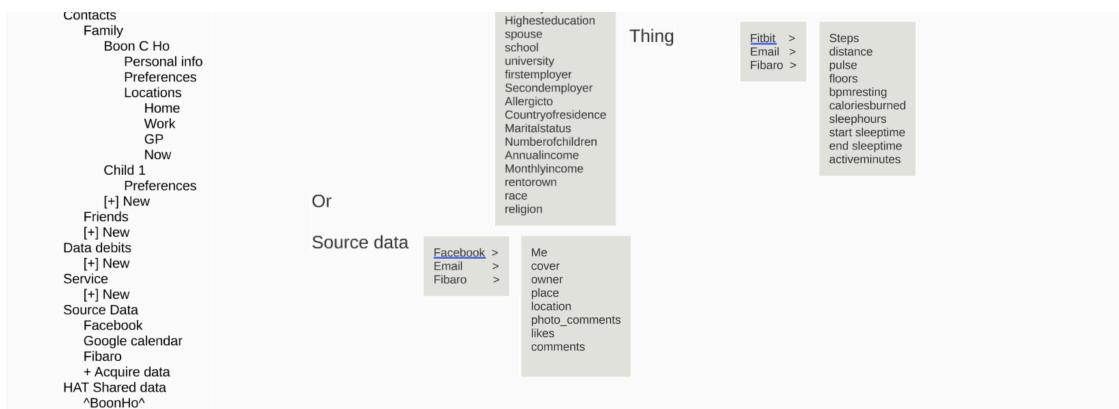
Collection Name: Personal information
Collection description: My personal info
Collection purpose: Up to date personal info for sharing

Assign source data from: [Pull down table of Source Data]

Fields listed include: First Name, Middle Name, Last Name, Weight, Height, Date of Birth, Place of Birth, Highest level of education, School, University, First employer, Second Employer, Allergies, Country of Residence, Marital status, Spouse, Number of Children, Annual Income, Renting or Owning of house, Race, and Religion.

Buttons on the right: **[+]** Assign from a vertical data source, **[x]** Share immediately (data debit will be automatically created), and **[i]** Add to bundle/collection.

At this point, the user may choose to link any data that comes from **HAT-Ready Services** to properties instead of entering their data manually, for example by linking Facebook Event data to an event they have created (see diagram below).



The combination of user-structured data and information coming in from sensors in our surroundings allow individuals to keep track of our location, share it with our contacts and

see our location, as well as visualise it in the HAT User Interface in real-time (see diagram below).

The screenshot shows the HAT Hyperdata Browser interface. At the top left is the HAT logo with the text "Hub-of-All-Things". The main area has a red header bar with the text "Hyperdata Browser" and a "Now" button with a refresh icon. Below this is a sidebar with a tree view of data categories:

- Collections
 - Me
 - Personal info
 - Finance
 - Wardrobe
 - Books
 - Music
 - Home
 - Preferences
 - Locations
 - Home
 - Work
 - GP
 - Local
 - Now
 - [+] New
 - Events
 - [+] New
 - Contacts
 - Family
 - Hubby
 - Personal info
 - Preferences
 - Locations
 - Home
 - Work
 - GP
 - Now

To the right of the sidebar is a map of a university campus. A red pin marks the location "Warwick Manufacturing Group Knowledge...". Other buildings labeled include the Mathematics Institute, University of Warwick; The Digital Lab; International Digital Laboratory; and School of Engineering, University of Warwick. Streets like University Rd, Library Rd, and Academic Loop Rd are visible.

*Technically, the previous data input from the devices/services (keys and values) will be associated with their **Units of Measurement**, and linked with **Properties** at this stage. The default **Units of Measurement** and **Properties** have been proposed by the HAT Data Exchange Foundation (HATDeX) upon consulting multiple sources (such as Schema.org, Freebase.com, Wikipedia, etc). HAT users can freely propose and edit them. The **Properties** are cross-referenced to the HAT's human data types: **Things**, **Person**, **Event**, **Location** and **Organisation**. Therefore, by creating a **Bundle** that combines the Person, the Thing, the Location, the Event and their associated properties, a HAT user is revealing how various vertical data sets have been connected in the living context. For example, a previous reading of 65 from a home body scale can now be reasoned as that a HAT user's weight was 65kg*

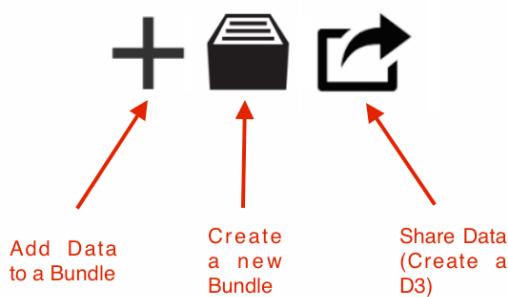
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*according to a particular body scale at home at a certain date and time. Multiples of such properties can be linked to the HAT **Person** to build up a comprehensive set of data for their "quantified self".*

*Each **Property** is therefore a **Collection** of data, either coming in from an external source or entered by the user as a set value. As the user becomes accustomed to their HAT, they will come up with new ways of organising their data obtained from the various data sources in the way that makes sense to them. For example, you create yourself as a **Person**, and give yourself **Properties** that you choose yourself. You either enter such data manually (such as your weight) or connect to an IoT device as the data source of that Property (e.g. Withings smart scales for your weight).*

***Collections** is the basic application which allows the user to make sense of their data. By creating collections, the user contextualises their data so that others can provide them with valuable applications that use the data. Importantly, however, it is not necessary to manually organise all of one's data at once: different applications ask for different sets of contextual data and some of them, e.g. those owned by the data input source developer will ask to retrieve the verbatim data from the HAT (necessarily through the Direct Data Debit system).*

With the Collections and Bundles, we now have a much richer contextualised data set compared to what the silo-ed device/service providers have. Hence, we are in the position to share our contextualised HAT data to bring us more personalised services delivered in context to make our lives even better. However, unlike the “good old ways” of giving our data away for free, the HAT allows us to control how the data is shared and with whom. The HAT adopts a **Direct Data Debit** concept (D3 System) on top of our **Bundles** to enable data sharing and exchange (a Data Debit forms the exchange unit of personal data exchange in this ecosystem). Any data that belongs to the user can be bundled and shared from any **Collection** or directly from **Source Data** (e.g. Facebook), either at the level of individual



properties or entire collections of data. To enable applications, the user will be recommended various popular data exchange collections, which include data from data collections and sources specified by the developer. This will be discussed in further more detail in a later section on Application Providers (see 2.2.1).

Collections	Popular Data Exchange Collections		
Me	Market2Me (bundle ID03768)[xxxxx users] [xxxx vendors] [see benefit]		
Personal info	Sourcedata	Field	Your data
Finance	Personalinfo-->	Preferredcoffeeroast	[full]
Wardrobe	Personalinfo-->	Preferredcoffedrink	[double espresso]
Books	Personalinfo-->	Preferredsugarlevel	[1]
Music	Personalinfo-->	Preferredmilk	[none]
Home	Personalinfo-->	Comfortfood	[noodle soup]
Preferences	Personalinfo-->	Favouritecolour	[you currently have no data on this]
Locations	iPhoneGPS-->	Latitude	54,345656
Home	iPhoneGPS-->	Longitude	0.78686
Work			
GP			
Local			
Now			
Events			
[+] New			
Contacts	MyJrny (bundle ID395673)[xxxxx users] [xxxx vendors] [see benefit]		
Family	Sourcedata	Field	Your data
Boon C Ho	Googlecalendar	time+3 hours	1530hrs - 1830hrs
Personal info	Googlecalendar	location	multiple GPS location
Preferences	iPhoneGPS-	Latitude	54,345656
Locations	iPhoneGPS	Longitude	0.78686
Home			
Work			
GP			
Now			
[+] New			

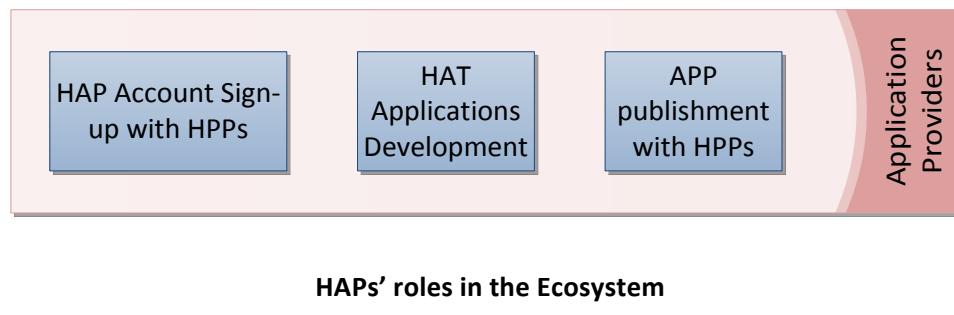
The HAT's **Direct Data Debit** or D3 System works like a direct debit in a bank: We can decide exactly **what data** (our bundles) to share, for **how long**, to **whom** such data may be exchanged, and **what return** may be offered in the exchange. In this way, other individuals and application can exchange their data/services with us - but only if we have agreed to do so. More importantly, we can choose to "**Sell**" or "**Rent**" our data. "**Sell**" follows the "common" data-sharing mechanism where we allow a third party to take our Bundled data from our HAT and process it at a third party server. "**Rent**" is the recommended HAT mechanism where we request the 3rd party's data analytics application to physically process our Bundled data locally at our HAT. In this case, the service runs locally on the HAT without any right of sending any data outside the HAT. For example, an app analyses our fitness habits, suggests certain things to buy, but does not send any of the analysis data back up to the application provider.

HAT-to-HAT data sharing further improves control over what happens with our data. When data is shared between HATs, it also goes through the D3 System. However, another HAT's data is never stored in our HAT locally, thus preventing us from exposing other individuals' private data as part of our own data debits. It does not, however, prevent us from using their data with our applications: the data is fetched on-demand as required by an application. For example, an application that shows real-time location of our network of friends and is based on the **Rent** model requests location data through the D3 System and shows our friends' locations to us in its User Interface, but this data is not stored in our HAT. If, on the other hand, an application is based on the **Sell** model but still wanted to make use of our data bundle that combines our own data with that of our friends, each of our friends will receive a request to approve a data debit with that application, which will in turn be retrieving the data from them individually instead of relying on us to expose it.

2.2 The HAPs and HPPs level

2.2.1 HAT Application Providers (HAPs)

The ability to exchange for richer/contextualised personal data gives the **HAT Application Providers** (HAPs) the incentive to pre-define Bundles and make offers via Direct Data Debit on the Bundles. Specific incentives include foreseeable revenue through analysing personal data, providing personalised goods and services (eg customised healthcare and well being) in exchange for data, or simply selling user applications to view, analyse and use their own data privately without sharing. Therefore, users will not have to define the bundles themselves; they just need to preview and decide if they agree with the proposed bundle configuration. Once agreed, users will also be able to authorise or terminate Data Debits for the exchange of data on the HAT. Bundle suggestions and Data Debit proposals will be built into HAT applications that users may install onto their HATs. It is just like managing mobile applications on our smart phones; we, install, update and delete our HAT applications via the HAT App Market (operated by HPPs).



All of such data exchange activities – Bundle suggestions and Data Debit proposals – can only communicate with a Personal HAT via the HAT APIs (via inbound or management APIs) so that data (metadata) can come in for the user's review and approval. If the user approves the data bundle and creates a Data Debit, only then can the data be accessed as defined by Data Debit. Namely, all applications and other HAT users can only access the granted Bundles in a contracted manner defined by Data Debit without any other accessibility to the user's data.

There are three examples with different functionalities to further illustrate the details of how applications access your data: data tracking (e.g. quantified-self), direct marketing (e.g.

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Market2Me) and data sharing (e.g. Social Data). All three use your personal data to create a valuable experience for you, but do so in different ways.

- A quantified-self application would use the **rent** data model to provide you with a dashboard with which you can analyse your sleep, fitness, eating habits, provide you with an activity planner that fits with your work calendar, etc. It would suggest to you a data bundle based on data sources you already have as well as other data sources you might be interested in (do you already have a Fitbit?), use the data to build the dashboard, but it would never send any data anywhere else.*

The screenshot shows the HAT Hyperdata Browser interface. At the top is the HAT logo with the text "Hub-of-All-Things". Below it is a navigation bar with links: "Hyperdata Browser", "Collections", "Me", "Personal info", "Finance", "Wardrobe", "Books", "Music", "Home", "Market2Me", "Locations", "Home", "Work", "GP", "Local", "Now", "Events", "[+] New", "Contacts", "Family", and "Boon C Ho". Under "Boon C Ho", there are links for "Personal info", "Preferences", "Locations", and "Home". To the right, under "Market2Me", there is a table showing data items:

	Market2Me	+	☒
Preferredcoffeeroast	[full]		
Preferredcoffeedrink	[double espresso]		
Preferredsugarlevel	[1]		
Preferredmilk	[none]		
Comfortfood	[noodle soup]		
Location	[Me>Locations>Now]		

Below the table, there is a message: "The above service is requesting for your data". There is also a checkbox: "[] I agree to the terms and conditions for sharing this data". A note states: "This data debit will be valid from [xx/xx/xx] to [xx/xx/xx] or [indefinitely]". A red button at the bottom right says "share now".

- The Market2Me application is more sophisticated: it provides you with product and food recommendations in your vicinity, and therefore it would want to access your current location and other personal data to build up your profile, to combine it with its own database of offers. To do so, it could either **buy** your data, process it and send you recommendations, or more appropriately for the HAT, **rent** it, run the recommendation app on your HAT and only retrieve its own offers to match with your data without leaking any of your information. In the above example, the application is **buying** your data, therefore you have to approve the **Bundle** of data they are requesting, agree to their terms and conditions for sharing this data and*

choose the validity period of the share – you should not have to share data indefinitely with a service that you only use once!

3. *Finally the Social Data app is similar to quantified-self, but uses data from multiple individuals to provide its functionality (e.g. showing some of your friends' locations in real-time on a map when you're trying to meet up). In this case, the application runs on your HAT; however it needs to **buy** (where you pay for their data with your own data rather than money) your friends' data by requesting them to set up a specific data bundle that it needs and to approve a Direct Data Debit for you to access the data.*

A HAP will need to be registered with a HPP to leverage the HPP's unique technological advantages, and launch/update its applications on the HPP's App Market subject to certification by the HATDeX. For example, a HPP may have access to data sets such as weather, live transportation data, and shopping/dining locations and busy times. A smart travel application can combine such data with a request for the next three hours of a HAT User's calendar to help the user make much more accurate travel plans, and potentially to suggest alternative solutions.

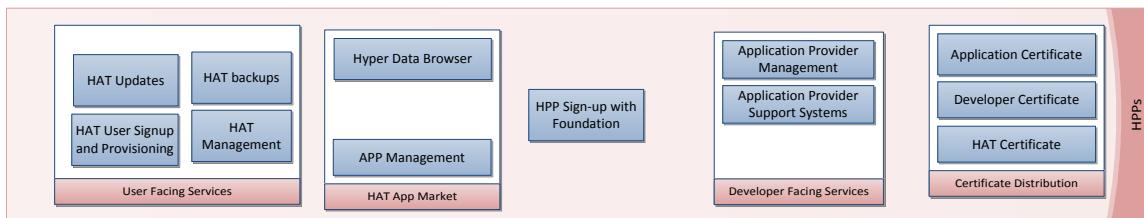
By leveraging on the openly available HAT DB schema and APIs, it is possible for some developers to develop experimental applications without signing up with a HPP and avoiding HATDeX certification. However, such applications will consequently lose the network effect of the entire HAT community and the ability to exchange with other HATs, as they will neither be certified by the HATDeX, nor be listed in any of the HPPs' App Markets.

2.2.2 HAT Platform Service Providers (HPPs)

HPPs are the hosts for Personal HATs (micro-cloud servers) and HAPs, to make HATs and Applications available to individuals on a freemium basis. HPPs integrate third party data sets and provide intermediary data services to the wider community of firms such as HAPs to

develop and publish their HAT Apps. HPPs also operate the App Market for HAT Users to obtain applications.

Two HPPs have signed up with the HAT Foundation prior to the release of this documentation: UK-based Enable iD (<http://enableid.com>) operating in Europe, and Singapore- based Noggin Pte Ltd (<http://nogginasia.com>) operating in Asia.



HPPs' roles in the ecosystem

2.2.2.1 HPP Sign-Up with HATDeX

HPPs are required to sign up with the HATDeX; HPP Sign-Up is a process for a potential HPP to obtain certification as an approved HPP. A potential HPP will need to propose a chosen technology stack (such as database engines, hosting services, etc) for its platform to host Personal HATs and provide other related services, then undertake the HATDeX's HPP Certification Procedure. HPPs are NOT limited to certain technology stacks by the HATDeX as long as they follow the HATDeX regulatory advice. Once approved, a HPP will be issued a HPP GUID, and can start providing their services to other parties in the ecosystem.

2.2.2.2 User-facing Services

A HPP provides Personal HATs to HAT Users, and would normally offer a collection of User-facing services that include:

1. **HAT User Sign-Up and Provisioning:** Each HPP may recruit their HAT users, and provide a provisioning system to deploy and maintain Personal HATs for the signed-up users. Even as a hosting service, **HPPs can only exchange data with Personal HATs via HAT APIs**, namely to propose bundles and direct data debits and to request users' permission for the exchange.

2. HAT Updates: HPPs will download the most up-to-date version of the Personal HAT from the HATDeX, to assure the compatibility and stability of the Personal HAT with its technology stack, and update HAT Users' Personal HAT to the latest version.
3. HAT Backups: to provide backup services for Personal HATs
4. HAT Management: HPPs are responsible for the management functions of personal HATs. This is driven by the HPPs' technology stack. Example functions may include VM (Virtual Machine) Management, API Hosting Service Management, etc

2.2.2.3 Certificate Distribution Services

Each Certified HPP will be provided (by the HATDeX) a number of Certificates at different levels to be distributed to the corresponding parties in the ecosystem, including:

1. HAT Certificate: This is the HAT Certificate (GUID) for individual HAT User's Personal HAT. Each HAT provisioned and hosted by a HPP is associated with a HAT Certificate.
2. Developer Certificate: HPPs will distribute Developer Certificates during their developer sign-up procedures. Each Developer is associated with one Developer Certificate.
3. App Certificate: HPPs will distribute App Certificates when developers publish their HAT Apps. Each HAT App is associated with one App Certificate.

2.2.2.4 Developer-facing services

A HPP will provide a technology environment with its unique technological advances to attract HAPs to develop and publish HAT applications. Developer-facing services provided by the HPP include:

1. HAPs Management: Management services such as Certificate distribution, association between HAPs and HAT Apps.
2. HAPs Support System: A portal that HAPs can use to manage their development-related activities such as managing HAPs Certificate and App Certificate, and requesting certificates to access other data sets from the HPP.

2.2.2.5 HAT App Market and the Hyperdata Browser

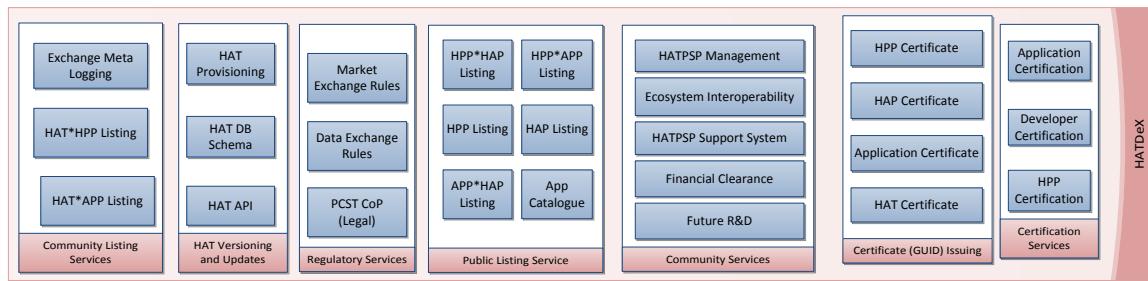
A HPP may also operate its own HAT App Market, where HAPs can publish and advertise their applications and users can download the application and provide reviews and feedback.

In the App Market, the Hyperdata Browser is featured as a default app that any HPP should provide for the HAT Users to browse their personal data. The Hyperdata Browser provides a data browsing and visualisation interface, as well as HAT management functionality. The user employs the Hyperdata Browser to contextualise their data, connect new sources of data, set up data bundles and authorise Direct Data Debits. In addition, it is used to manage all other user applications. Due to the rich functionality and management functions provided, the Hyperdata Browser is a privileged application that uses an additional set of APIs not available to other applications.

2.3 HATDeX level

In order to support the containment of personal data and to facilitate its exchange in this HAT ecosystem, the HPPs and HAPs will need to provide assurance that platforms and apps are compliant with a “HAT standard” on Privacy, Confidentiality, Security, and Trust (PCST) as well as take on the role of a trusted body for financial transactions between HAT Users and firms. Thus, a community-based foundation – the HATDeX – emerges that would manage and regulate the HAT ecosystem.

The HATDeX is positioned as a form of exchange, which provides regulatory rules and services for personal data (and other related personal data instruments) to be traded in the HAT-enabled ecosystem. It is similar to a securities exchange in the financial market for stocks, bonds and other securities. The HATDeX’s role is to nurture this personal data exchange ecosystem and roll out free HATs to individuals worldwide. To achieve this, the HATDeX will offer a number of services to the community.



HATDeX's roles in the ecosystem

2.3.1 PERSONAL HAT Baseline Technology Versioning and Updates

First of all, the HATDeX develops and updates the baseline technology for Personal HATs, and makes the technology available to the entire HAT community. The baseline technology essentially is the components that make up the Personal HATs, including:

1. Provisioning system for HAT Database
2. HAT Database Schema with Data Dictionary
3. APIs (inbound and outbound) for applications to communicate with HAT Database
4. Other applications developed by the HATDeX; this may include a default Hyperdata Browser for Personal HATs, and Applications to connect other HAT-Ready Services (by the Nov 2015 release, this will include Fibaro Systems, Facebook, Google Calendar, Cube Sensors, Fitbit, Withings)

These components have been packaged with relevant documentations as free downloads from the HAT Github at <https://github.com/Hub-of-all-Things/HAT2.0>. Our database schema is licensed under the Creative Commons Attribution-NoDerivatives 4.0 International (<http://creativecommons.org/licenses/by-nd/4.0/>) for free distribution among the HAT community.

2.3.2 Regulatory Services

The HATDeX creates and regulates the HAT ecosystem on behalf of the community of HAT Users, HAPs and HPPs, in order to facilitate healthy exchanges of personal data between all parties in the ecosystem such that value is created for individuals and firms alike. The

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HATDeX proposes a number of regulatory and exchange rules to regulate the activities in the ecosystem, including:

1. Market Exchange Rules – how financial exchange should be conducted within the ecosystem
2. Data Exchange Rules – how personal data exchange should be conducted within the ecosystem
3. PCST Code of Practice – how Privacy, Confidentiality, Security and Trust (PCST) of personal data should be conducted within the ecosystem

2.3.3 Certification Services

Certification services are the procedures that the HATDeX will operate to ensure that all parties in the ecosystem will strictly follow the rules defined by the regulatory services. Certification applies to the following:

1. HPPs – through a HPP certification procedure to **certify** and accredit all HPPs.
2. HAPs - through a HAP certification procedure to **Certify** and accredit all HAPs.
3. HAT Apps – through a HAT App certification procedure to **Certify** and accredit all HAT Applications developed by HPPs and HAPs.

Subject to successful certification, all parties from this list will be issued a GUID as a globally unique identifier in the ecosystem through the Certificate Issuing services.

2.3.4 Certificate (GUID) Issuing Services

This involves the provision of Global Unique Identifications (GUID) for certified parties in the ecosystem. There will be four major GUID lists provided by the HATDeX:

1. GUID for each individual Personal HAT: GUIDs will be anonymised
2. GUID for each HPP
3. GUID for each HAT App
4. GUID for each HAP

Except for the Personal HAT Certificate, all other certified parties will appear in the HATDeX's public-facing lists.

2.3.5 Public Listing Services

The HATDeX's public-facing lists are from its services listing all certified parties in the ecosystem for the general public to view, including:

1. Listing of all certified HAT Apps
2. Listing of all certified HAPs
3. Listing of all certified HPPs
4. Listing of HPP-HAT Developer association: which Developer is currently registered with which HPP
5. Listing of HPP-APP association: which HAT App is currently registered with which HPP
6. Listing of HAT APP-HAT Developer association: which HAT App is developed by which HAT Developer

2.3.6 Community Listing Services

Another set of listing services are designed to primarily service the HAT Community and enable the HATDeX to provide the data exchange functionalities within the community. These listing services will only be visible to the associated parties in the ecosystem, including:

1. Personal HAT/HPP Listing: To specify which HAT is hosted by which HPP via Personal HAT GUID association with HPP GUID. This is visible to the HATDeX and HPPs.
2. PERSONAL HAT/HAT App Listing: To specify which HAT has which Apps installed via Personal HAT GUID association with HAT App GUID. This is visible to the HATDeX and HPPs. HAPs will have limited visibility to the list that contains their HAT APP GUID.
3. Listing of fully anonymised Meta logs of data exchange. This is a listing of all agreed data exchanges with the associated meta information. The record in this list will include the value/duration/type of the Direct Data Debit, and the **Meta data (property names associated with Thing, Person, Location, Event and Organisation)**

without the actual values) of the Bundle. GUIDs are not shared. This is visible to all members of the HAT community.

2.3.7 HAT Community Services

The HATDeX's global HAT rollout will offer a choice of HPPs for the hosting of individuals' micro-cloud HATs. This requires financial clearance and interoperability in the transactions between HPPs, HAT Users and HAT Developers globally within the personal data exchange ecosystem. To nurture such activities, the HATDeX will provide:

1. HPP Support System: A HPP service portal that HPPs can use to manage their HATDeX-related activities such as managing HPP and HAT Certificates, listing associated HAPs, etc.
2. HPP Management System: A portal for the HPPs to manage their pure HPP-dependent service with their own tooling, such as Certificates distribution, association between HPPs and HAT Users and HAT App Developers (this will not be released by Nov 2015)
3. Interoperability: This is assured at both Personal HAT and HPP levels:
 - a. Personal HAT (provided by certified HPPs) interoperability is realised as all Personal HATs will follow the HAT Database Schema defined by the HATDeX
 - b. Data exchange interoperability is achieved through the use of unified HAT APIs, as all parties in the ecosystem can only communicate with Personal HATs via HAT APIs published by the HATDeX
4. Financial Clearance: The HATDeX will provide mechanisms for and act as a financial clearing body for transactions among HPPs, HAPs and HAT Users. E.g. finance clearance for a HAT App purchased through HPP2's App Market but developed and published on HPP1's platform.
5. Continuous Research and Development: The HATDeX will also enable research to continue and innovation to thrive within the HAT ecosystem through innovation labs and an open-sourced experimental community.

An ecosystem overview with all parties and their functions is illustrated in a diagram on Page 27.

3. Future Road Maps for HAT Tech

Over the course of the research, the HAT Project team has evaluated numerous technologies and adopted a few future-proof technologies to ensure the HAT's continuity. Developing HAT alongside of the rapidly advancing technology landscape, the team has also identified a few key technology areas for future work and improvement for existing HAT technologies. The long-term plan is to evolve the HAT into a schema and a set of protocols that is software-agnostic and freely interoperable.

3.1 Database

The HAT Database Schema is designed to be able to accommodate any data structures exchanged by online service APIs, especially focusing on the JSON format. Data is stored in a relational Database by defining virtual data schemas for each source of data. A mechanism based on data cross-references is used to maintain all original data structure and establish new links between different data points to reformat data for export and contextualisation. The schema resembles NoSQL databases in its flexibility and a NoSQL-based solution (e.g. using Graph Databases due to focus on links between data points) could be provided in the future. It is also likely that the database license would evolve to become a Creative Commons ShareAlike license so that the community can help improve it.

3.2 Micro-Server

To facilitate full user control over their data and improve privacy guarantees, each user owns a micro-server that hosts their HAT database, the software layer providing APIs over the database and management functionality and the Hyperdata Browser providing the User Interface. Each HAT is therefore a self-contained personal data storage solution that can be run independently. The current solution is based on the containerisation technology, where each application stack runs in complete isolation but reduces the cost of running it on a complete, powerful server. As the unikernel technology (such as the OSv or MirageOS) matures, the HAT will likely adopt it for a more efficient HAT that can run on tiny platforms

such as the Raspberry Pi in user's home, along with their other decentralised services such as mail or file sharing.

3.3 APIs

The Application Programming Interface (API) of the HAT is designed to facilitate communication between individual HATs and services that use their data using the standard JSON data format. The APIs are split into inbound, outbound and management. Inbound ones are used by data sources to provide data to HATs and use the flexible data schema outlined above. Outbound APIs operate with the Data Debit mechanism, where the user approves each data user with each kind of data to be retrieved. They facilitate the only method of retrieving data from a HAT. Finally, management APIs are used by the Hyperdata Browser to contextualise data, control Data Debts, authorisation, applications and other management functions. Further work on the APIs focuses on providing users with help in contextualising their data as well as suggesting to the overall ecosystem (users and applications) what data bundles would be beneficial to have and what other data sources would bring the most value when connected to the HAT.

3.4 Demonstration Technology Stacks for HATPDP

By Nov 2015, the HATDeX will release two technology stacks for HATPDPs:

1. Microsoft .Net + Microsoft SQL Server – this will be utilised by Enable iD as their HPP technology stack.
2. Scala + PostgreSQL – this will be utilised by Noggin Asia as their HPP technology stack.

3.5 Data Trading Protocol

Blockchains are in the future roadmap to remove the need for a centralised transaction verification between data provider (user) and data consumer (service). This further improves privacy of the overall system but also allows for a more sustainable cryptocurrency design, where new currency is generated by adding valuable data into the ecosystem. Technologies

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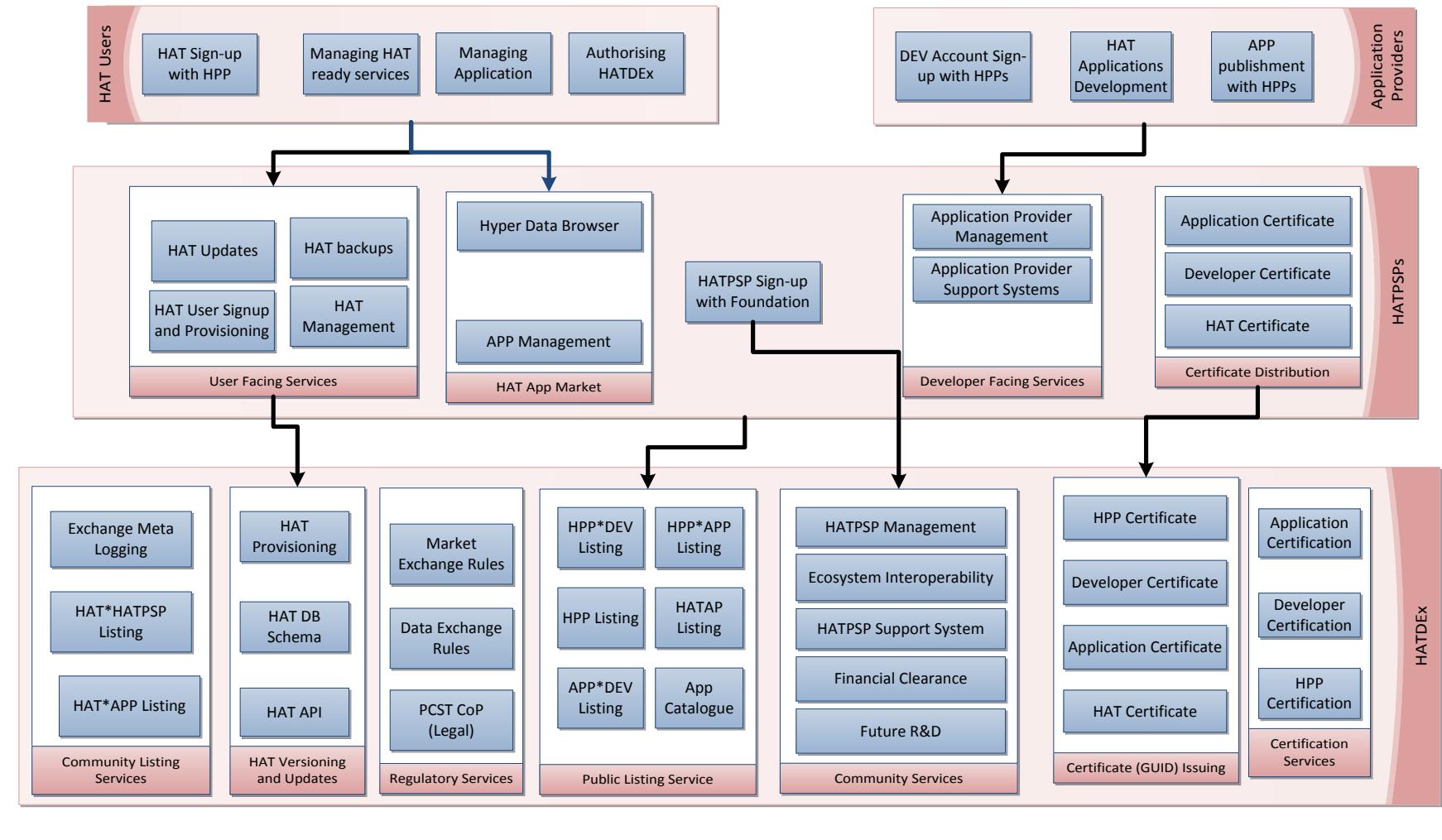
already developed around Bitcoin, such as the Bitcoin's scripting system, could further enable more automatic contract enforcement between data trading parties.

3.6 Exchange Platforms

The HATDeX is undertaking discussions with a few large enterprise system providers to identify a good exchange system.

3.7 Interoperability

Each HAT is part of the global HAT network, which allows individuals to exchange personal data through their HATs, run additional applications, trade their data with services and report transactions for validation and fraud detection. It is achieved through the core set of APIs implemented in every HAT and the most widely used protocols on the Internet: JSON for data encoding during exchange, HTTPS for end-to-end secure communication and DNS for HAT naming and discovery. The set of standards means that the HAT is already compatible with any Internet-connected device and will form a network that does not lock users into specific application or platform providers.



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Glossary of Terms

The HAT	A personal data platform developed by the <i>HAT project</i> that allows a HAT user to acquire, store, transform, view, sell, rent, trade and use his or her personal data. Also known as the HAT Personal Data Platform (HATPDP) or the Personal HAT
HAT-ready Device	A device that is able to send and/or receive data to/from the HAT in a way that is compliant to <i>HAT CoP</i> and certified by the <i>HAT project</i>
HAT-ready Service	A service that is able to send and/or receive data to/from the HAT in a way that is compliant to <i>HAT CoP</i> and certified by the <i>HAT project</i>
HAT Service	A service that runs on the HAT at all levels (platform, user, middleware etc.)
HAT User	An individual who owns and uses HAT data and integrates data from HAT-ready devices and services
HAT Data	Data from HAT-ready devices and services which the individual has access to that is acquired into the user's own HAT
HAT Event Data	A set of HAT data that is brought together by the HAT user for a user-defined 'event'. HAT event data could be tracked by the user over time or shared, sold, rented, traded through the D3 system
HATPDP Provider (HPP)	An organisation that hosts users' HATs and supports a community of HAT developers by developing HAT services that improve the HATPDP capabilities
HAT Developers	Individuals who create HAT services who could be working for HAT service providers
HAT Service Providers	Organisations who provide a HAT service on the HATPDP
HAT Participants	HAT developers, HPPs, HAT users, HAT service providers

HAT CoP	A set of practices that all HAT participants subscribe to
The D3 System	The Direct Data Debit (D3) system or the Data Debit system on the HAT that enables the access of personal data on an individual's HAT
HAT Project	The £1.2m RCUK Digital Economy-funded project of 6 universities led by WMG, University of Warwick that would evolve into an open-sourced, community supported foundation
HATDeX Foundation	HAT Data Exchange Foundation, an organization that would manage and regulate the HAT ecosystem. Positioned as a form of exchange, it will provide regulatory rules and services for personal data (and other related personal data instruments) to be traded in the HAT- enabled ecosystem.
HAT Application Provider (HAP) A HAT Service Provider	
HAT App Market	A Marketplace of HAT applications where HAT users can buy or download to visualise, analyse or use their data
Personal HAT	See The HAT for definition
HATPDP	HAT Personal Data Platform; see the HAT for definition
GUID	Globally Unique Identifier to serve as the identification for a particular HAT in the ecosystem.
HAT Hyperdata Browser	A 'browser' of how data is linked to other data in other places and a way to view the linkages and clusters of data
HAT Database Schema	The 'blueprint' of how HAT organises data based on the ontology of how we believe human beings organise data and which serves to inform the way in which the HAT database is constructed.

Roles on the HAT Ecosystem

HAT User

Description: An individual who owns and uses HAT data and integrates data from their HAT-ready devices and services

Functions:

1. Users register with a HATPDP Provider for a HAT
2. Users are given a unique HAT ID
3. Users authenticate their identity and access to their HATPDP Provider
4. Users acquire data from HAT device(s) and service(s) onto their HAT
5. User personalises their HAT through bundles or collections
6. Users lookup and check personal data on their HAT
7. Users can create an event and decide what HAT data is relevant to the event
8. Users can track their HAT data
9. Users can export their HAT data for sharing or to be used, bought or rented by third parties through the D3 system
10. User can see their list of D3s and transaction history
11. User can control their D3 system rules such as cancelling or modifying a D3

HAT Project/HATDeX

Description: The £1.2m RCUK Digital Economy-funded project of 6 universities led by WMG, University of Warwick that would evolve into an open-sourced, community supported organisation

Functions:

1. Appoints and licenses the HATPDP hosting by HPPs
2. Supports HPPs with technical, economic and business advice
3. Advises on how devices and services can be HAT-ready
4. Reviews requests for HAT certification of HAT-ready devices and services
5. Certifies if devices and services are HAT-ready
6. Enables the download of HATPDP and its versions for HAT users by HATPDP providers
7. Maintains and updates the HATPDP
8. Maintains and updates HAT inbound APIs of all HATPDPs
9. Maintains and updates HAT outbound APIs of all HATPDPs
10. Maintains and updates HAT store catalogue of all HAT-ready devices and services
11. Manages the Framework of Accreditation on HAT service providers

12. Manages the HAT unique ID database of HAT users
13. Advises on economic and business models of the HAT
14. Regulates financial and economic conditions within the HAT ecosystem
15. Approve pricing structures of HAT applications and charge policies of HATPDP providers

HAT Developer

Description: Developers who create HAT services

Functions

1. Develops HAT services that enable the sharing, buying, renting or operating of user applications on HAT data
2. Maintains working version of the HAT services
3. Provides regular software patches and updates to maintain the HAT services
4. Notifies the HATPDP provider when the HAT services are changed or deleted from use

HATPDP Provider (HPP)

Description: A platform provider that hosts users' HATs and supports a community of HAT developers by developing middleware capabilities

Functions:

1. Defines the level that the HPP will operate the HAT database and service for a HAT user
2. Provides users with a HAT environment.
3. Ensures security of data on behalf of the HAT user
4. Ensures confidentiality of data through access control
5. Validates the service rules for event creation and data debit generation with the compliance of the user
6. Validates the data debit privacy rules
7. Validates data debit usage rules
8. Enforces the service rules and usage rules to enforce the privacy requirement

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<http://hubofallthings.com>



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