Liquid Experience

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Abstract:
This paper describes an exploratory investigation undertaken into a proposed architecture for a so-called "Experience Framework". The Experience Framework is a platform to develop and deploy future web-based services and devices that support rich user experiences and allow these experiences to be enhanced when multiple devices are brought together. We believe that only by considering people, devices and services together, as an inter-dependent eco-system, can rich, natural, life-integrated user experiences be created. Realizing the Experience Framework as a set of reusable components provides the agility to design, build and deploy new services and applications at a speed and cost more closely aligned with the rapidly changing Web 2.0 world. The flexibility of the framework architecture allows it to be opened up to promote a consumer developer community and the creation of experiences that are operating-system independent.

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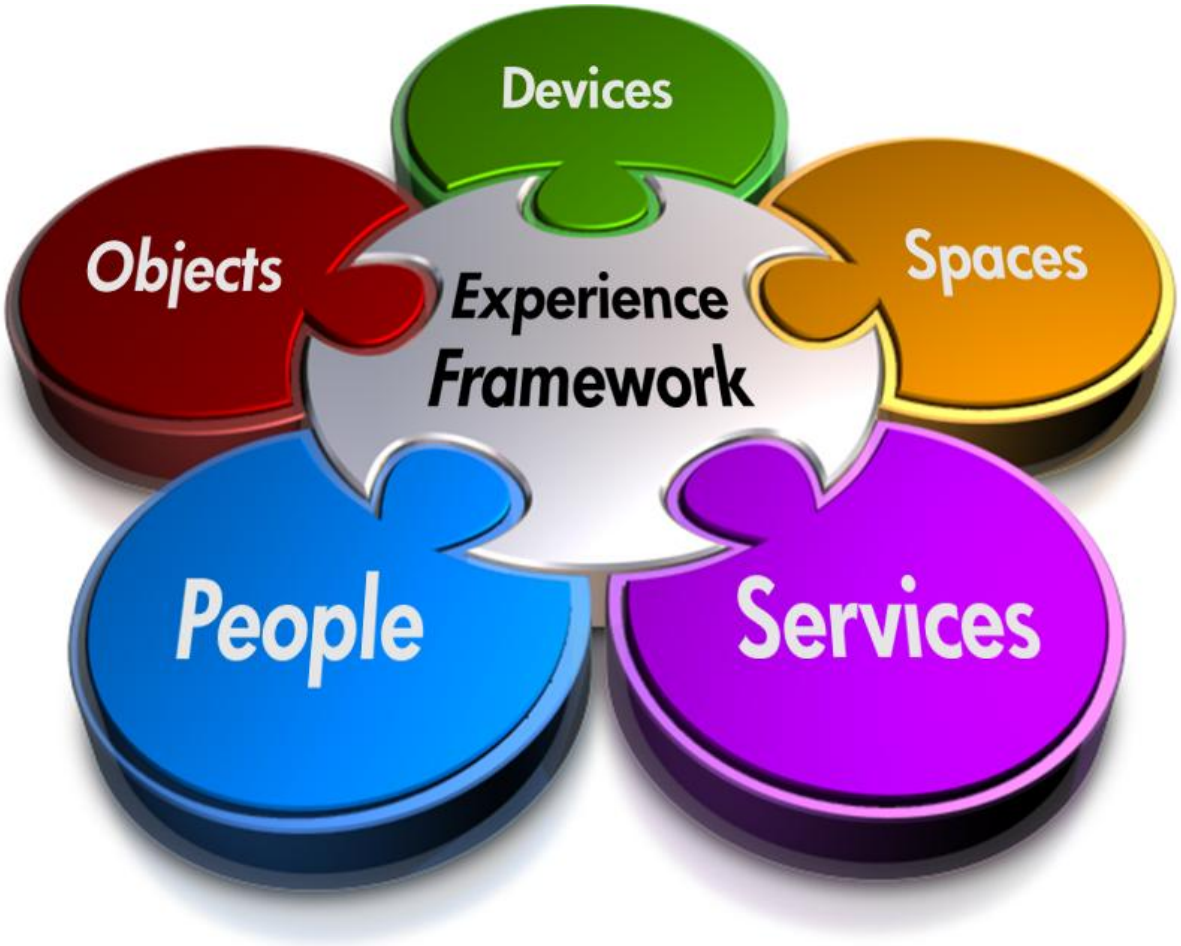


Executive Summary

The way that people use devices has changed radically in recent years. Increasingly people are attracted more by great interaction design and the quality and value of the personalised device-service experience than by the technical specifications of devices and their connectivity.

Our vision of the future is one where the digital world will become more physical and the physical world will become more digital. People will be surrounded by an environment which will be enhanced with an ever-increasing array of devices and other digitally enfranchised physical objects. The PC will continue to be an important platform but it will no longer be central, as new device form factors, mobility and cloud-enabled services introduce compelling new experiences. People will be able to own multiple devices and migrate to new ones without facing the complexities that they do today, and will interact with them in an easier, more natural and personalized way.

Underpinning this vision will be a myriad of pervasive cloud-based services delivering content-rich and social-rich experiences. The difference between services in the future and those available today will be the unique way in which the experience is mediated, shaped and enhanced by devices. Devices will be specialized both in form and function for the delivery of particular cloud-based services and appropriate interaction with people.

Our goal is to produce the *Experience Framework* - a platform to develop and deploy cloud-based services and devices that support rich user experiences and allow these experiences to be enhanced when multiple devices are brought together. We believe that only by considering *people*, *devices* and *services* together, as an inter-dependent eco-system, can rich, natural, life-integrated user experiences be created; this is unique to our approach. We propose bringing all this work together in a series of comprehensive demonstrations of the technology.

In the area of *services*, we will prototype a number of exemplars to illustrate the capability of our platform, its ability to operate with services provided by other vendors and to showcase compelling user experiences. For *devices*, we plan to investigate and develop technologies that enable intuitive and unambiguous association and interaction between devices within a person's interaction space. We will also explore new device classes that are tightly coupled to cloud-based services. The research in the area of *people* will employ user studies to analyse prototype services and devices. The results from this will inform and guide subsequent designs as well as the *Experience Framework.*

This research project will create business value by transferring technology and a deeper understanding of *experience* that together will enhance HP's ability to offer a quality differentiated user experience that is consistent across a portfolio of devices and services. We believe this will add significantly to PSG's already considerable steps it is making to offer richer user experiences through device and service innovation.

Realizing the research goal as a framework of reusable components provides HP with the agility to design, build and deploy new services and applications at a speed and cost more closely aligned with the rapidly changing Web 2.0 world. The flexibility of the framework architecture will allow it to be opened up to promote a consumer developer community and the creation of experiences that are operating-system independent.

We propose that this work be carried out over a 5 year period, initially with a team of 10 engineers. In order to accelerate innovation, we intend to leverage our efforts through multi-national research collaborations funded by EU and other government bodies and through relationships with universities.

1 Research Contributions

1.1 Problem Statement

In our vision of the future, people and their communities will interact with a digital world comprising numerous devices, objects, spaces and cloud-based services.

Today we are seeing a trend towards people owning and managing many devices – devices that are differentiated by form, function and by usability more than by their technical capabilities. In the future people will access many different cloud-based services provided by many vendors, some provided free, some ad-sponsored and others paid for by subscription.

This new world presents its own problems – how can rich experiences be delivered to people that allow them to seamlessly use their numerous devices to access services to which they have subscribed? How can the capabilities of their devices and services be combined to offer these new experiences in a way that is transparent to the user? How can new services and devices be offered to people that complement, extend and enhance their existing set in a way that simply "just works"? How can PSG ensure that the experience it offers is "better on HP"?

Solving these problems is the goal of this project, and to achieve this we need to:

- Better understand how people like to interact with devices, services, user communities and the physical, smart, environment.
- Make devices intuitively work both singly and together, to present the best experience for a person's particular circumstance and environment.
- Be able to rapidly deploy services that provide a consistent level of experience, and that are easily and intuitively accessed through a variety of device types and forms.

1.2 Technical Challenges and Approach

Our project, as illustrated in Figure 1 will comprise areas focusing on people, devices, services, objects and spaces tightly coupled through the *Experience Framework.* Truly differentiated experiences cannot be achieved without considering all of these areas in unison and in particular paying attention to the network of relationships between them.

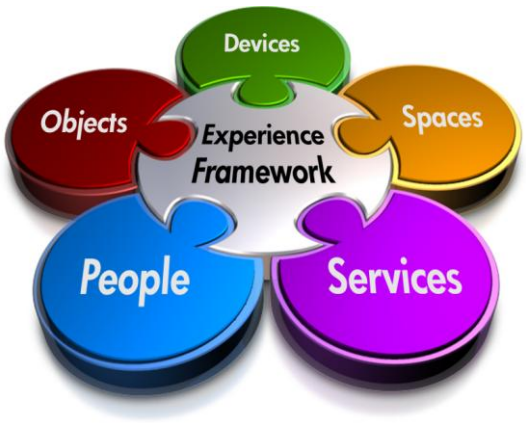


Figure 1

We intend to explore the fundamentals of creating compelling digital experiences for people, to generate business value for HP and advance the state-of-the-art.

For *Devices*, we consider an eco-system that comprises not only devices but also digitally enfranchised physical objects[1] and physical spaces[2]. For *Services*, the eco-system describes the role played by services created by HP and those provided by 3rd parties. The *People* section refers to the individual and community aspects of the experience. Our final section, the *Experience Framework*, describes the platform of reusable components with which we build our devices and services.

[1] See http://www.nfc-forum.org/specs/ Smart Posters enabled by NFC are an example of a digitally enfranchised physical object.

[2] Physical spaces are considered as a collection of objects with some form of spatial metadata

The *Experience Framework* will be shaped by the results of our research into the other areas. Equally the way in which we create and validate new experiences through devices and services will be based on the evolving set of components available in our framework. Our research will be an iterative process with each cycle further refining our understanding of the framework, devices and services. To seed the iterative process we will start with a baseline framework and set of scenarios, covering devices, services, and experiences.

As part of the ongoing validation process the project will create, or make use of existing, trial and demonstration facilities, such as the Connected Home in Cupertino [REF] in order to measure and refine the research goals. The facilities will provide the project with an opportunity to demonstrate and test new devices and services in a variety of real world settings and with people outside of the immediate project team.

1.2.1 Device ecosystem

Challenges

In the device ecosystem, the main challenges we face are:

- Rapid creation of compelling device types that will be tightly coupled to services in the cloud.
- Provide the user with the ability to unambiguously and intuitively select a device, object or service within the user's immediate environment – room, office, shop window, etc.

The following paragraphs outline the current state-of-the-art for technology relevant to these challenges and how we intend to work on these.

State-of-the-Art

A number of consumer electronics manufacturers are actively exploring how to deliver compelling experiences for people, through a variety of internal and collaborative research programmes.

Motorola's Physical and Digital Realization project [REF] is one of the key programs which is exploring experience from a device perspective and is closely related to our proposed research. In particular the program is exploring how Motorola can create devices which natively interact with physical environments whilst fitting into the lifestyle of their audience. Intel is also active in this area, with a focus on components for devices, and has a set of projects exploring context awareness [REF] and mobility [REF]. A number of other companies are also active in this space; the full list can be seen in appendix A.

For the device association element of our work there are several competing technologies that might be considered relevant. These can conveniently be grouped in to two categories: proximity and vicinity.

Proximity association methods typically associate two devices by requiring them to be physically brought together in close proximity, typically 0 to 10cms, thus reducing any ambiguity about which two devices are being associated. Although these techniques generally work well, because they require the user to physically bring the devices together, they are not always particularly convenient and do not align well with our vision of the future. Some established technologies that can be used for proximity association are: NFC[3], Irda[4] and NTT DoCoMo skin touch[5].

[3] http://www.nfc-forum.org/home

[4] http://www.irda.org

[5] http://www.redtacton.com/en/

Vicinity association (a few metres) typically uses technologies which, by their nature, have communication ranges that are only loosely constrained; range is significantly affected by environment and is generally not directional, thus unambiguously identifying devices within a user's vicinity becomes a process of inquiry and subsequent elimination of superfluous contacts, often through heuristic methods. Examples of technologies that occupy this space are Bluetooth/WiFi/Zigbee etc. (wireless <3GHz), 60GHz wireless and diffuse IR.

Approach

The Device Ecosystem refers to the multiplicity of devices we envision in the future, their form and function and their relationship with other devices, services and people. This section outlines our approach to the device ecosystem and its relationship with our other areas of research.

Interactions that people have with devices, through keyboards, mice, touch screens and similar are suitable for today's services. However, the move to a more complex set of cooperating devices and services, will require new means of interaction. In particular we will consider how natural interactions such as movement, pointing, orientation and physical tokens can be used to perform interactions that would otherwise be overly complex using today's capabilities.

We intend to leverage existing technologies such as RFID, Open Source Software such as Android as well as create new technologies where appropriate in order to build novel prototype devices that typify the level of end user experience that we believe will be a significant differentiator for HP in the future.

We have defined the following device classes that we aim to explore:

- *Ubiquitous display surfaces* – "everything is a surface"
- *Fixed Devices* – Devices that will occupy the same space as the current desktop PC.
- *Mobile Devices* – MIDs, UMPC, Laptop, Handheld
- *Tokens* – Digitally enfranchised physical objects. These allow purely digital items to be manifested physically for example the 'Infinite USB stick' [REF our IP]

along with the following related device technologies:

- *Reality Augmentation*
- *Device Association*
- *Device & Token Identification*

As outlined in the research challenges section, the ability to use multiple devices in concert in an ad-hoc and intuitive way is one of the critical unsolved research problems. Our approach to the device association problem will deliver a solution which will unambiguously identify one or more devices within a person's vicinity. This process will determine unique identifiers for these devices that can then be used by the Experience Framework's resolution processes. Technologies that we will investigate include the following:

- Controlled-range near-field techniques
- Directed visible light communication
- Audio / Ultrasound
- Hybrid RF/Diffuse IR systems

All these techniques provide the potential for low-cost solutions, and to varying degrees the ability to leverage and extend existing technologies and standards that have already been deployed for quite different applications. They also provide opportunities to advance the state of research in constrained communication, with potential for spin-off in other application areas.

1.2.2 Service Ecosystem

Challenges

The key technical challenges are to understand how to give cloud-based services a physical presence and how to enable new services to be created that are accessed via a myriad of new, novel device classes. Specifically:

- *Service Architecture* – How do we define an architecture that allows for new services to be rapidly created and for service composition across a broad range of providers (not just HP), whilst maintaining a control point for HP?
- *Interfaces and Protocols* – What are the interfaces and protocols that will allow experiences to be mediated across devices and service and between multiple services?
- *Service Offering* – What are the exemplar service offerings that are compelling for people whilst providing a valuable role for HP? What requirements do these exemplars place of a service framework?
- *Security, Identity, Trust, Privacy, Rights* – How can a rich environment of services and devices maintain trust and privacy across a system containing numerous parties, and a highly dynamic user base?
- *Performance and Availability* – How can the user experience of accessing cloud-based services through devices be made equivalent to that of using a system that is entirely local and therefore maintain an illusion that the experience is running locally, even though it is actually being delivered by multiple cloud-based services interacting through the internet?

State-of-the-Art

Microsoft, today through their 'Live' [REF] services and going forward through their Azure Service Platform [REF] are actively working and researching service ecosystems. Because of their current dominant position and there large number of consumer touchpoints, it is important to follow their activities closely.

Amazon and Google are two other majors organizations with dominate positions and an existing presence in the service ecosystem. Amazon, through their EC2 [REF] and S3 [REF] services, and Google, though their entire range of services and their operating system, Android, are both currently setting the standard in Web Based service ecosystems, and will be aiming to drive the space forward, on their own terms.

Services such as Facebook, Flickr and YouTube will play a major role as application and content providers in our vision of the future, but the focus of our research will be more towards creating a platform to accelerate the creation of the next generation of social network and media sharing services, rather than creating the services themselves.

Appendix A gives a list of related technologies in the service ecosystem space.

Approach

The Service Ecosystem refers to the various classes of services that we are considering, their role and relationship with other services, devices and people.

Our approach is that each device has a corresponding service in the cloud, this enables new services, devices and capability to be created or existing ones expanded in a simpler and effective way.

In order to do this, we need to create a service architecture that is flexible and easily extendable. At the same time, we must realize that there will be an ecosystem of services, some provided by HP and many others by third-party providers. Our technical approach will ensure that our own and third-party services can work together and we intend to explore control points in the ecosystem that allow HP to

establish a pivotal role, maintain touch-points with users and potentially collecting revenue for service transactions.

In our approach, we define three classes of service:

- *Virtual Device Services* - Represent a digital instance of a physical device and implement the cloud-based part of the end-user application, which spans a device and the service.
- *Framework Services* - Fundamental services that are required in order for the experience framework to operate. The set of component services is discussed in greater detail in the Experience Framework section. We will also ensure that security, trust, identity, privacy and rights are dealt with correctly by defining the appropriate policy and leveraging appropriate standards and technologies.
- *Content Services* - Provide digital content, data and other capabilities that are consumed by virtual device services. Social networking, photo sharing, photo printing and file backup are all examples of content services that we wish to be able to integrate into our experience framework.

We intend to leverage existing web service interfaces and standards and define new interfaces and propose new standards where appropriate to ensure that the classes of services can interact as required by the experience framework. We also intend to prototype services of all classes and integrate with existing services to drive requirements of the experience framework and also to illustrate its capabilities and extensibility. This is part of our iterative approach to the research.

We will look to emerging cloud computing platforms, highlighted in the State of the Art section, as a basis for our services and will prototype device/service combinations to aid our understanding of how devices will discover and access cloud-based services and how many services from different providers can work together to provide a richer experience.

1.2.3 People

Challenges

The *People* area refers to the individual and community aspects of the experiences described in our vision. There are many general definitions of the user experience. [refs to NormanNielsenGroup definitions, Apple developer definitions]. Strictly speaking 'user experience' refers to what the user feels when they use the system in question. When we talk about 'designing or creating a user experience', what we are actually doing is designing and creating the parts of the system that the user interacts with and that we expect will cause the user to have the desired experience. The success of this will depend on how well we understand the user experience and the way it is shaped by the user's interaction with the system.

The system in question can be anything: we can deal with the user experience of a single product or the user experience of an entire brand or enterprise. While the scope of the former is clear cut, the latter encompasses aspects such as brand perception prior to purchasing products/services, sales after-care, repeat purchases, etc. - in effect the user's entire emotional relationship with the brand. Whether it be a single product or an entire brand, if we are to instil feelings such as trust, satisfaction, pleasure etc. then we need to understand how different factors create the user experience.

In our proposal the user experience that we are dealing with is the user's experience of a collection of services aggregated through a concierge-style service and delivered through a collection of devices. This is a large and important component of the brand/enterprise user experience and it encompasses several of the touch-points between the user and the enterprise, ensuring that these were handled consistently and in a manner to maximize customer value.

Although user experience is a relatively new subject in the world of digital services, it has a long history in non-digital services. One of the classic examples is the hotel. A hotel is an aggregated collection of services, some of them third-party, that are unified and delivered to the user under one 'umbrella' service. The hotel must work to ensure that all parts of the users experience are as good as possible, and to ensure that the user is aware that the hotel is doing its best. Often the overall experience provided by a hotel is judged, not on those things that go well, but on how well the hotel deals with things that go wrong. The user/customer has to be left with a feeling that the service provider is on their side when dealing with problems. Existing service design is a rich resource when considering user experience as emotion and experience.

The challenges in this area are:

- To achieve an understanding of the constituents of user experience that can be used in the design of the user aspects of both devices and services. The user experience involves many qualitative aspects such as pleasure, trust, confusion, and thus is difficult to quantify and analyze.
- To apply this knowledge in the form of good practice throughout the iterative design and evaluation of devices and services.
- To incorporate this knowledge into the experience framework.

State-of-the-Art

There are a few companies which are approaching the space we are interested in from an open, user centric perspective: Philips, a consumer electronics company, has invested in a user-centric approach to experience research; the results of their research to date can already be seen through their AmbiLight and related product lines. Philips, through their Experience Research [REF] program, has built an Experience Lab where they perform user analysis of their devices in real situations. The Experience Lab consists of home, retail and office spaces within which trials are conducted and observed.

Of equal interest in the this space is Deutsche Telecom who, through their Intuitive Usability [REF] program is exploring how to improve both devices and services by understanding user behavior and applying degrees of personalization and filtering. As with the other ecosystems a full list of related programs and companies can be found in [REF].

Approach

The ability to include devices in service design and thus generate services that don't just end at the desktop is a key enabler to novel service creation. However, these two ingredients alone are not enough, they have to be supplemented with deep, user-centric design if the resulting service is going to succeed.

Our goal is to analyze and understand the issues involved in user experience, and to encapsulate this understanding within the Experience Framework. This will be achieved through research that investigates people's experience of:

- Real-world services
- Blended services (services amalgamated from third-party services)
- Resolution of service failure
- Cloud-centric computing and services (in particular; trust and user-models)
- Physical aspects of personal devices and objects
- Associating and mediating communication between devices
- Novel device types (including the identification of new types)

Areas of particular interest will include:

- Simple experiences – Ensuring that complexity is concealed or presented to people in as usable a manner as possible to provide experiences that are uncluttered and appropriate.
- Social experiences – Just as we are considering devices in terms of wider groups of devices so too we shall be considering users in terms of wider social networks of people. In particular what shapes the user experience of person-to-person communication and the user experience of sharing media.
- Personalised experiences – How the experience of services can be tailored to meet the needs and desires of particular demographics and individual users.

This understanding will be achieved by conducting and analyzing structured interviews with people regarding digital and non-digital services. We will also arrange evaluations of prototypes built in the course of the research. These prototypes will range from scripted simulations to restricted, working prototypes.

By working with the developers and considering design vocabularies we shall work towards incorporating good practice in experience design into the Experience Framework.

1.2.4 Experience Framework

Challenges

The overriding challenge of the Experience Framework is to design a platform, populated with novel enabling technologies, that allows experiences to be realised in a rapid, repeatable and efficient manner.

The framework must also meet the challenge of enabling both a differentiating "better on HP" experience and the best possible experience in a heterogeneous world of devices and services.

The framework must foster a developer's community, allowing individuals and groups to create their own experience through new devices and services, extending the potential of the platform beyond that which HP can realise on its own.

The final challenge for the Experience Framework is to deliver an architecture that is open, extensible and complete enough to form the basis for a white-label service, allowing HP to offer the framework to our partners who wish to realize the benefits within their own ecosystem of devices, services and people.

State-of-the-Art

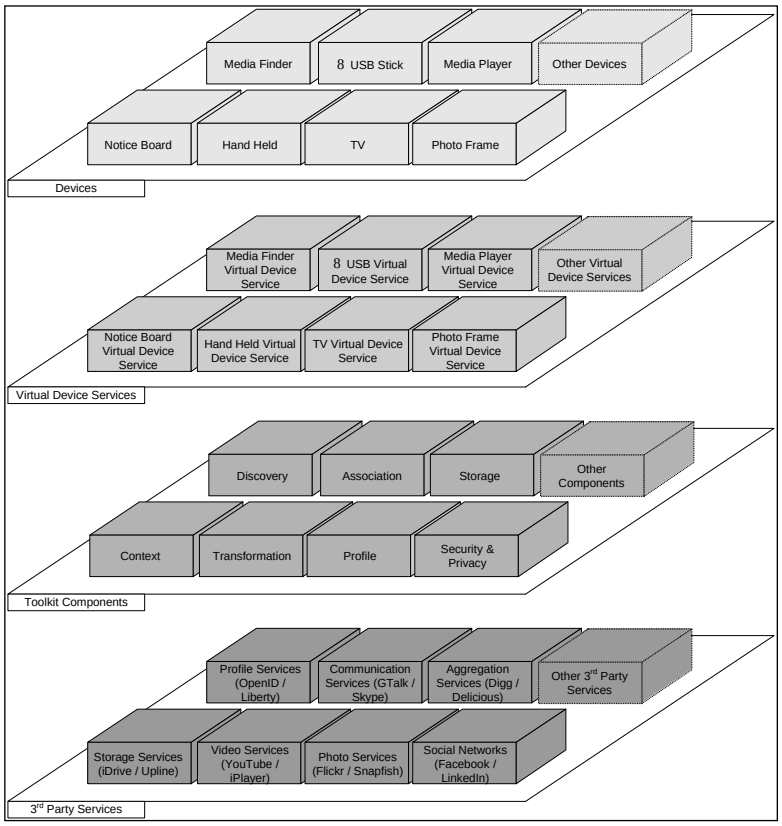
A framework which supports the development of experiences that takes into account device, service and people factors equally is a concept which a number of organisations see as offering significant opportunities in the future. However, few organisations have moved beyond the concept stage into design and realisation.

The W3C [REF] and OASIS [REF] organisations recognise the opportunities and are running a number of working groups developing standards and best practice for both technical architectures for cloud based services [REF: W3C TAG & UWA] and the individual components which form the enabling technologies [REF: OASIS XRI/XDI and W3C SMIL/MI].

Within HP the Experience Software Business [REF] is leading the strategic drive to deliver compelling and easy-to-use experiences across our range of devices and services. Underpinning the strategy is a unified technical and design philosophy with which we will align our framework research.

Approach

In order to realise the goals of the research areas defined previously, we will require a platform of reusable components, which we call the *Experience Framework*. The framework, which is a combination of HP IP, standards-based and best of breed 3rd party technologies, will enable us to prototype rapidly and repeatedly, accelerating the trial and validation phases of the research.



Beyond its value to the project itself we envision the framework being realized by PSG to help deliver unique cooperating experiences.

Figure 3 shows our baseline framework which will act as the primer for our iterative research approach.

The devices referred to in Figure 3 are instances of those described in the Devices Ecosystem section, which operates in partnership with an instance of a Virtual Device Service.

Devices access content, data and the capabilities of other devices through their own instance of a Virtual Device Service, described in the following section and shown as the blue communication lines in Figure 4. This type of communication is the responsibility of a service connectivity component.

In some cases devices may identify and interact with each other at a device-to-device level rather than through their instances of the Virtual Device Service, this is shown in Figure 4 as the red communication line and is the responsibility of the association component. In particular this type of device-to-device interaction occurs where two devices wishing to cooperate need to identify each other or where the experience requires a level of latency that cannot be achieved or guaranteed by the devices communicating via their instances of the Virtual Device Service.

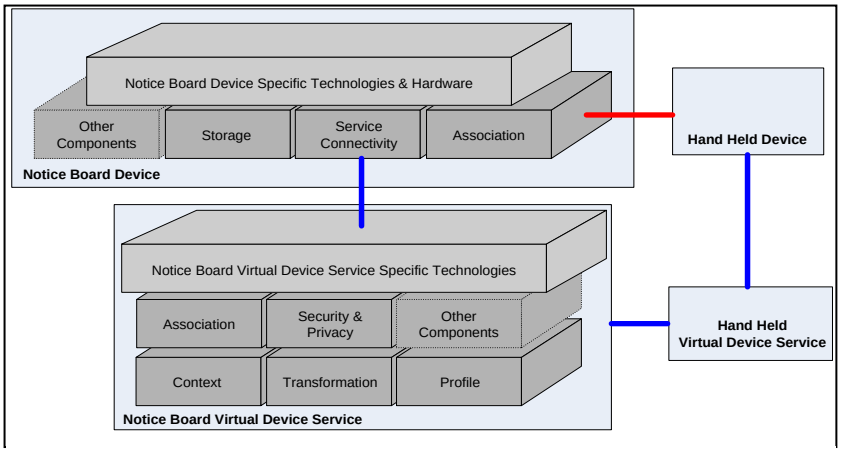


Figure 3 Devices and Virtual Device Services

Virtual Device Services, as shown in Figure 4, are built using the framework and can be thought of as representing a virtual instance of a physical device in the cloud which can be accessed to manipulate

content and mediate context and interactivity. Complex Virtual Device Services may be implemented as a combination of simpler ones.

The components are the building blocks on top of which the Virtual Device Services and the Devices are built. Our baseline framework, outlined below, describes the initial set of components which will be refined as part of our iterative research process.

- *Context:* Responsible for storing both sensor data from devices (for example GPS location and orientation) and offering a query interface which can be used to infer higher level information. Context is typically used as input to other processes, such as discovery and security.
- *Transformation*: Responsible for converting between media formats such that source data is suitable for use by a particular device or service.
- *Profile*: Responsible for holding or referencing to 3rd party services which contains descriptions, definition metadata and relationships relevant to a particular entity. The set of entities which may contain profiles is defined as: Users, Devices, Objects, Spaces, Services and Groups.
- *Security*: Responsible for privacy, access control, rights and policy.
- *Discovery*: Responsible for discovering specific instances of entities for which there is a profile.
- *Association*: Responsible for ad-hoc and permanent device identification and association.
- *Resolver*: Responsible for resolving unique identifiers into references to a service instantiation.
- *Storage*: Responsible for providing temporary (cache) and permanent storage capability.

In order to extend the variety and quantity of devices and services beyond that which HP could achieve on its own, the framework will encourage and support a developer's community. By providing a software development kit, supporting open standards and publishing our interface definitions the framework will allow individuals and groups to create their own experiences. Whilst such an approach comes with its own challenges, chief among them maintaining quality and ensuring suitability of the experiences, they will be far outweighed by the benefits of an active development community.

1.3 Related/future Research

Research in other HPL Groups

We plan to leverage the work of other projects within HP Labs and work closely with projects where our research activities complement one another. In particular, the *Pervasive Media* project within our own Lab shares some of our vision. Their work on context and authoring fits alongside our own areas of research and we aim to ensure that where it makes sense, we can combine forces to a make a larger overall contribution.

The *Trusted Virtualized Clients* project focuses on providing trusted environments on client devices. We see security and trust as an important area, but not one where our expertise lies, or where we intend to invest effort. We will look to leverage security expertise from this groups in order that the experience framework addresses issues in security, trust and privacy.

The work on cloud platforms and cloud computing infrastructure within HP Labs also has relevance and we will ensure that we are cognizant of their work as it progresses such that our own work related to services is consistent with the HP's emerging approach to cloud computing.

Other projects of interest include *Intuitive Multimodel and Gestural Interaction (IMaGIn), InfoPal, Receptors, Chameleon* – all of which have relevancy to our own proposal. We will engage with these project teams and leverage their work and/or work together, as necessary.

Research outside HP

Universities worldwide have identified pervasive computing as an important area of research, however their scope is mostly limited to the areas of grid computing, network infrastructure and smart spaces. Most universities focus on individual research areas such as devices or user interfaces, rather than considering them together, as inter-dependent areas.

The vision of the *EU Real World Internet* and *The Internet of Things* promotes a future world where the multiplicity of tags, sensors, and actuators provide physical world information enabling new classes of applications combining virtual and physical world information. Their areas of research include architecture and technologies for novel internet-based applications, optimised technologies covering distribution of intelligence and Architectural models enabling an open governance scheme of the Internet of Things. This vision fits alongside our own and we will look to engage as appropriate.

Research into technologies relevant to device association is, in the main, focused toward the usual application of short-range networking, and for near-field technologies, traditional applications of RFID. Work in the area of Visible Light Communications (VLC)[6] is also networking focussed, mainly directed toward developing systems that could provide an alternative to the current short-range wireless networking technologies such as Bluetooth and WiFi; there has also been some work investigating its use as an alternative to NFC[7].

There are also standardization activities that are looking into areas related to/aligned with this proposal– the W3C's *Ubiquitous Web Applications* has a charter that includes "enabling value-added services and business models for ubiquitous networked devices, based upon W3C's strengths in declarative representations". The IPSO Alliance's *IP for Smart Objects* is "…an open, informal and thought-leading association … that promote[s] the value of using the Internet Protocol for the networking of Smart Object".

The OASIS *Extensible Resource Identifier (XRI)* standard is a scheme and resolution protocol for abstract identifiers compatible with Uniform Resource Identifiers and Internationalized Resource Identifiers". It aims to enable resource discovery and definition and may provide a globally unique identifier scheme that can be leveraged. The MPEG group's *MPEG-21 Digital Item Adaptation* standard aims to specify "a comprehensive set of description tools that can be exchanged and used for enabling the optimized adaptation of multimedia content". We see this work as potentially contributing towards the capability for the generic transformation of content between services and devices.

[6] Presentation to IEEE802.15 9th March 2008. Visible Light Communication:Tutorial. *IEEE 802.15-<08/0114-02>*

[7] Private conversation with Mr C Chaplin of Samsung during the Nov 4th 2008 Ecma TC47 Standards meeting. Mr Chaplin is considering making a proposal to Ecma TC47 to develop a communications standard for Visible Light Communications that would leverage many of the attributes of the current NFCIP-1 Near field Communications standard currently being used by the NFC Forum.

Appendix A State-of-the-Art

A.1 Device Manufacturers

Company	Title	Description	Ecosys.
Intel http://techresearch.intel.com/articles/Mobility/1565.htm	Context Awareness and Sensors. Refining Mobility, performance and efficiency	Using context to tune devices to user's present situation. Smart power usage across processors and radios to extend the battery life for mobile devices. Other interesting research strands include: Human Activity Recognition, Cultural Computing and Place Lab - Ubiquitous	Device User
Motorola http://www.motorola.com/content.jsp?globalObjectId=6677-9298-9301 http://www.motorola.com/content.jsp?globalObjectId=8253 Other interesting activities include social mobile gaming: http://www.motorola.com/content.jsp?globalObjectId=8252	Physical and Digital realization Nomadic Device Gateway	Researching the convergence of physical and digital worlds, with many overlapping themes with our proposal. Gateway technology which provides context aware control of devices, smartphones, MP3 players and similar, in a car. Interesting quote from Motorola Research director about NDG: "…right information, at the right time, anywhere and from any device"	Device User Service
Philips http://www.research.philips.com/focused/index.html	Experience Research	Experience based research centre designed to shape future Philips CE and other technologies. May of their ideas have manifested themselves in products such as Ambilight.	User Device
Apple http://www.apple.com	iPhone / iTouch	Innovative Mobile Internet Devices (MID) & Portable Media Player (PMP) with close coupling to cloud-based service.	Device
Fujitsu http://jp.fujitsu.com/group/labs/en/business/activities/activities-4/	Making interfaces effortless	A number of user experience research strands including ubiquitous communication and colour bi-stable flexible screens	Device User
IBM http://domino.research.ibm.com/cambridge/research.nsf/pages/cue.html?Open http://www.research.ibm.com/ed/ Many other themes: http://domino.research.ibm.com/comm/research.n	Collaborative User Experience Everywhere displays	Business focused research into collaborative user interfaces and environments. Augmented reality technologies with user tracking.	Service Device

sf/pages/d.compsci.html			
Nokia http://research.nokia.com/research/index.html	Mobile platforms, context services, HCI, Mixed Reality and IoT Symbian operating system	A number of related research threads from mobile internet devices, context services, user interfaces and mixed reality to scalable services and the Internet of Things. Recently fully acquired Symbian operating system and plans to make it available as open source.	User
Nvidia http://www.nvidia.com/page/handheld.html http://www.nvidia.com/page/pp_preface.html	Tegra Platform and Preface	Tegra is a low power / high graphical performance mobile devices platform. Preface is an embedded hardware solution to run Microsoft SideShow and similar applications.	Device
Sony http://uk.youtube.com/watch?v=opUEXlX8iwo	Cell processor, Playstation 3 and augmenting reality	Consumer electronics gaming device with Internet connectivity and HD video capabilities. Sony are planning to release games and entertainment services which use a video camera as a means of augmenting reality and increase the immersiveness of the experience.	Device
Sun http://research.sun.com/projects/dashboard.php?id=85	Collaborative Environments	Programme converging multiple research strands, looking at improving the experience of distributed collaboration.	Service
Thomson http://www.thlab.net/Research%20Domains/Opportunistic%20communication%20and%20Pocket%20Switched%20Networks/	Opportunistic communication and Pocket Switched Networks	Using novel technologies and techniques to route data where standard networks are not available.	Service Device
Asus	Eee PC	Low cost sub-notebook form factor that kick started the market.	Device
EyeFi http://www.eye.fi/	EyeFi SD Cards	Wireless LAN enabled SS memory cards, enabling upload of photos/videos directly to online services from the device (camera etc…) without requiring a PC or other connected device.	Device Service
HTC	Xperia X1 and G1 smart phones	Manufactures Windows mobile based smart phones, the majority of which are badged by third parties.	Device
INQ Mobile http://www.inqmobile.com/	INQ1	Social Networking oriented smartphone for UK based 3G network operator 3	Device
NEC http://www.nw.neclab.eu/	Context-aware Services	Co-ordinating a number of context awareness programmes into a single approach.	Service
Nintendo	DS and Wii Gaming Platform	Pioneering the use of touch / transforming input mechanisms (DS) and motion based gaming.	Device
Palm http://www.palm.com/us/products/index.html	Handhelds and Smartphones	A variety of handhelds and smartphones based on Palm OS	Device

Panasonic / Matsushita http://www.panasonic.co.uk/html/en_GB/1838907/index.html#anker_1838824	Panasonic Research & Development	Focus on rugged design to specialise laptops and tablet PCs for particular environments, industries and tasks.	Device
RIM http://www.blackberry.com/blackberrystorm/	Blackberry Storm	A smartphone built using RIM's own OS and includes the interesting SurePress technology, which provides haptic feedback for the touchscreens.	Device
Sharp http://www.sle.sharp.co.uk/research/optical_imaging/3d_research.php	Sharp Research - Optical Imaging	User tracking 3D (stereo) display technologies for laptops and mobile phones. Founding member of the 3D consortium.	Device
Tikitag http://www.tikitag.com/	Tikitag	RFID tag and reader kit aimed at non-technical users	Device Service
Toshiba http://www.toshiba.co.jp/tech/review/index.htm	SpursEngine	3D and video processing oriented microprocessor designed for consumer electronics with applications in gesture interfaces and face detection.	Device
Violet http://www.nabaztag.com/en/index.html	Nabaztag	Internet access device with a unique form factor and interface.	Device Service User
3M http://www.3mmpro.com/	Micro Projectors	One example of a micro project technology	Device
Archos http://www.archos.com/products/imt/index.html?country=global&lang=en	Internet Media Tablets	Media-centric Internet tablet device	Device
Creative http://uk.europe.creative.com/products/product.asp?category=830&subcategory=831&product=17761	Vado	Small digital video camera with direct sharing capability with online services.	Device
Dell	DisplayPort	Screen connection standard, designed to replace DVI.	Device
Polaroid	PoGo	Handheld, portable photo printer with direct camera connection.	Device
Sony-Ericsson http://www.sonyericsson.com/x1/	Xperia X1 Mobile Internet Device	Windows Mobile 6.1 based smart phone / mobile internet device	Device

Services

Company	Title	Description	Ecosys.
Microsoft http://www.microsoft.com/azure/default.mspx	Azure Services Platform	Software platform for building cloud-based applications.	Service Device
Microsoft http://dev.live.com/	Live Services	The Live framework provides a framework for developers to access Microsoft Live Services. Designed to enable:	Service Device

		Cloud/Client/Device reach: An easy way to build applications which span cloud/web and devices **Access to user-data:** Simple to integrate user data, social graph, etc. **Application ecosystem**: A way to build apps which can be seamlessly discovered, deployed, and managed across a user's Mesh and shared with others **Easy to get started**: You can use existing skills, no need to re-write, available from variety of platforms, devices, programming language	
Amazon http://aws.amazon.com/	Amazon Web Services	Platform and software for cloud computing.	Service Device
Google http://code.google.com/android/	Android	Open-source mobile software platform. Although pitched as a platform/OS for mobile phones/devices, Android could be used as a platform for a wide variety of devices.	Device
SalesForce.com http://www.salesforce.com http://www.salesforce.com/uk/platform/	SalesForce.com	Web-based CRM solution. Often cited as one of the best examples of a successful cloud-based service. SalesForce have their own cloud-platform named force.com which they offer as a platform-as-a-service for third-parties to build their own applications.	Service
Adobe http://www.adobe.com/products/air/	AIR	Software to allow developers to build Rich Internet Applications (RIA) that run on a variety of operating systems.	
Microsoft http://silverlight.net	Silverlight	Microsoft's equivalent of Adobe AIR.	
Microsoft http://www.microsoft.com/SURFACE/index.html	Surface	Microsoft's platform for surface computing. Software layer on top of Windows that works with specific hardware	User Device
LongJump http://www.longjump.com/	Platform At Your Service	LongJump is an on-demand platform for creating and delivering business applications	Service
Good OS http://www.thinkgos.com/	gOS / Cloud	Browser-based operating system – provides an OS delivered through a web-browser.	Device
Google http://code.google.com/appengine/	App Engine	Platform for building web applications that are hosted by Google	
Coghead http://www.coghead.com/	Coghead	Platform for building and delivering applications in the cloud. Hosted by Amazon.	Service
Apple http://www.apple.com/mobileme/	MobileMe	Cloud-based service that allows multiple devices to sync with the data stored by the service. The service offers email, contacts, calendars, photos and files.	Service Device User

SkyFire http://www.skyfire.com/	SkyFire	Provides a consistent web experience on mobile devices. SkyFire performs appropriate format conversion etc, to allow mobile devices to view the same web content available to a PC-based browser.	Service Device User

Network Operators

Company	Title	Description	Ecosys.
BT http://labs.bt.com/barc/Projects.html	Pervasive Information Architecture Future Applications Services	A range of collaborative research projects in the pervasive space, in particular the Pervasive Information Architecture and Future Applications Services programs are most relevant	Service User
France Telecom / Orange http://www.orange.com/en_EN/innovation/	NExT (New Experience in Telecommunications)	A set of projects exploring how the company moves from network access to service access, independent to the connection technologies.	Service User
Deutsche Telecom / T-Mobile http://www.laboratories.telekom.com/ipws/English/InnovationDevelopment/Usability/Pages/default.aspx	Intuitive Usability Integrative Service Components	The Intuitive Usability program is looking at device and service usability through various personalisation, filtering and automated configuration techniques. The Integrative Service Components programme is looking at enabling everyday objects to become connected by exploiting the range of existing access technologies.	User Service Device
Telecom Italia http://163.162.17.244/servicelab/progetti.htm	Service Lab	User Focus service design lab, current a key partner in the FP 6 MobiLife project	User Service
Hutchinson Whampoa / 3 http://www.three.co.uk/personal/mobiles_/inq.omp	INQ1	Mobile device built by INQ (wholly owned subsidiary of Hutchinson) with tight integrate with Facebook social network	Device Service
AT&T http://www.research.att.com/viewProject.cfm?prjID=104	4G Wireless LANs	A variety of research themes, mainly network focused; of particular interest are the projects related to 4G mobile networks as they provide a potential for a truly ubiquitous high speed network.	Service
Telefonica / O2 http://research.tid.es/usermodeling http://research.tid.es/internet/	Data Mining and User Modelling Research Group Internet Group	A research lab taking a human-centric approach to data mining in order to provide means of better and more relevant service personalisation. Focuses on cloud computing and online social networking.	User Service
Telenor http://www.ilabs.no./index.php/eng	iLab	A research program setup for the promotion of open standards with the services and device development community. Recently released an open source mobile application development kit.	Service Device
KPN http://www.kpn.com/corporate/en/company-	Things are talking	A program looking at the Internet of Things and in particular its role within intelligent buildings	Service

profile/innovation.htm			
Blyk http://www.blyk.co.uk/	Blyk	Mobile network operator providing advertising funded free calls and texts to its exclusive customer base of 16-24 year olds.	Service Device

World-wide Standards Bodies and Consortia

Standards Body or Consortium	Activity	Description	Relevance	Ecosys.
NFC Forum	http://www.nfc-forum.org/home	"…promotes the use of NFC short-range wireless interaction in consumer electronics, mobile devices and PCs..	Standards for device association using near-touch	Device
Ecma	NFC WG TC47 http://www.ecma-international.org/memento/TC47.html	"To develop Standards and Technical Reports for Near Field Communication Systems, for the realization of simple wireless communication between close coupled devices for network products and consumer equipment."	Standards for Near Field Communications	Device
IrDA	http://www.irda.org	".. a nonprofit organization whose goal is to develop globally adopted specifications for infrared wireless communication."	Technology relevant to short-range device association	Device
ISO/IEC JTC1, SC6, SC31	RFID and Near-Field communications standards	Telecommunications and information exchange between systems and Automatic identification and data capture techniques	Standards for device association using near-touch and also potentially for vicinity association	Device
W3C	Ubiquitous Web Applications http://www.w3.org/2007/uwa/	"… enabling value-added services and business models for ubiquitous networked devices, based upon W3C's strengths in declarative representations".	Provides an environment (authoring tools) to support our "making the physical digital" approach. Provides baseline for device profiles.	Service
IPSO Alliance	The IP Smart Objects Alliance http://www.ipso-alliance.org/Pages/Overview.aspx	"…an open, informal and thought-leading association … that promote[s] the value of using the Internet Protocol for the networking of Smart Object"	An IoT enabler.	Service
W3C	Synchronised Multimedia (SMIL) http://www.w3.org/AudioVideo/Activity.html	Standardised multimedia mark-up and layout.	Relevant to the Rendering and Transformation components	Service
IETF	IPv6 http://www.ietf.org/rf	Delivers a larger address space and removes the need for	An enabler to bring all devices and sensors	Service

	c/rfc2460.txt	levels of obfuscation such as NAT.	online in an IoT vision and also provides a potential globally unique identifier	
OASIS	Extensible Resource Identifier (XRI) http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=xri Related Standard: XRI Data Interchange (XDI)	"…a scheme and resolution protocol for abstract identifiers compatible with Uniform Resource Identifiers and Internationalized Resource Identifiers"	Enables resource (device/sensor etc…) discovery and definition and may act as a globally unique identifier.	Service
MPEG	MPEG-21 Digital Item Adaptation http://www.chiariglione.org/mpeg/technologies/mp21-dia/index.htm	"…specifies a comprehensive set of description tools that can be exchanged and used for enabling the optimized adaptation of multimedia content."	May provide capability for the generic transformation component.	Service
W3C	Rich Web Clients http://www.w3.org/2006/rwc/Activity.html	Standardising the approach for building rich Web clients.	Definition of applications layout and interaction relevant to device and user interfaces.	Service
W3C	Multimodal Interaction http://www.w3.org/2002/mmi/Activity.html	Dynamic selection of appropriate mode of interaction based on user or environment	Relevant to user and device interface and Rendering and Transformation components.	Service
W3C	HTML 5 http://www.w3.org/html/wg/html5/ Related forum: Web Hypertext Application Technology Working Group (WHATWG) http://www.whatwg.org/	Introduces features into HTML to make it more suitable for Web applications and to natively take advantage of richer content, such as video and audio.	Relevant to user and device interface and Rendering and Transformation components.	Service
W3C	Technical Architecture Group	"build consensus around principles of Web architecture .. resolve issues involving general Web architecture"	Relevant to the way in which we architect our own framework and services.	Service
OpenID.net	OpenID http://openid.net/	Aims to eliminate the need for multiple usernames across different websites, simplifying the online experience.	May enable our vision of devices accessing multiple 3rd party services seamlessly.	Service
Liberty Alliance	The Liberty Alliance Project http://www.projectliberty.org/	"…enable a networked world based on open standards where consumers, citizens, businesses and governments can more easily conduct	Provides a framework for distributed user profiles.	Service

		online transactions while protecting the privacy and security of identity information"		
DLNA	Digital Living Network Alliance http://www.dlna.org/home Related standards: UPnP and Zeroconf (IETF).	Promotes a standard for interoperability between consumer electronics.	Potentially relevant to device interoperability, e.g. association and transfer of content.	Service
OASIS	Device Profile for Web Service http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=ws-dd	"…defines a set of implementation constraints to enable secure Web Service messaging, discovery, description, and eventing on resource-constrained devices."	Potentially relevant for service discovery and composition. May also play a role in device profile	Service
W3C	Platform for Privacy Preferences (P3P) and Security http://www.w3.org/Privacy/Activity.html http://www.w3.org/Security/Activity.html	Providing a privacy and security standards-based framework.	Relevant to the security component and the wider security concerns	Service
ETSI / ITU / TISPAN	Next Generation Networks Global Standards Initiative http://www.itu.int/ITU-T/ngn/release1.html: Related Standard: 3GPP IMS - IP Multimedia Subsystem	A vision of all service becoming packetized to enabling service related functions to become independent from the underlying transported-related technologies.	Relevant to our vision of always connected devices.	Service
OSGi Alliance	Application Lifecycle Management http://www.osgi.org/Main/HomePage	"…offers standardized ways to manage the software lifecycle"	In an operational environment OSGi may provides an open, remote management capability to our multiplicity of devices.	Service

HP PSG

Activity	Description	Relevance
Experience Software Business http://intranet.hp.com/PSG/WW/ExperienceSoftware/Pages/index.aspx	"Develop HP experience software that gives people compelling, easy-to-use experiences and services on HP's personal computing devices."	Alignment with our overall project goals, EBU states that "creating great HP experiences for our customer" should be part of the charter for every group in HP. EBU owns the strategy to bring together a unified cross-device experience.
JetPack http://intranet.hp.com/PSG/WW/ExperienceSoftware/PublishingImages/jetpack.jpg	A Desktop-based interface to empower a user's interactions with the cloud.	Closely aligned with our strategy, although this has a desktop (today) slant to it.

Also related: Family Room http://intranet.hp.com/PSG/WW/ExperienceSoftware/PublishingImages/familyroom.jpg		
Mobile Internet Experience http://www.hp.com/united-states/campaigns/mini1000/hpmini1000_mie.html	"…Mobile Internet Experience (MIE) offers the online content and applications you want with just one click. Using the intuitive desktop, you can access email, internet, pictures, video, and music faster and more easily than ever."	A fully HP owned computing experience, delivered on a specialised device (e.g. a Mini Note Netbook with a cut-down functionality – e.g. no Windows)
Always Connected User Experience	A cross-HP (CTO lead rather than PSG) strategy and architecture for a vision of always connected and always synchronised services and devices.	The concepts of always connected and "synchronised" are key to our vision and the document also provides some, limited, user research relating to experiences and cloud-based services
HP TouchSmart PC http://www.hp.com/united-states/campaigns/touchsmart/alt/tsalt.html	Touch enabled all-in-one form factor PC with a thin layer of HP Experience Software.	Whilst the TouchSmart is a fully fledged PC, which can drop back to Windows, this device is interesting to us because when used with the TouchSmart software it can become a fully HP controlled experience which is an ideal platform for walk-up computing.
HP TouchSmart tx2 Notebook PC http://www.hp.com/united-states/campaigns/touchsmart/notebook/index.html?jumpid=re_r602_crosslink/ts_alt/tx2/home	Touch enabled notebook / tablet form factor laptop with a thin layer of HP Experience Software which is an extension of the TouchSmart PC layer and also provides true multi-touch.	Similar to the TouchSmart PC although the mobility of the device (it is a small notebook, 12.1 inch screen that can fold back like a tablet) offers the possibility for us to use it as a platform for other, more mobile scenarios.
iPAQ Data Messenger / Voice Messenger http://h10010.www1.hp.com/wwpc/uk/en/sm/WF05a/215348-215348-64929-3352590-3352590-3806501.html	Consumer-oriented Smart-phones with large, touch-enable screen.	Another potential platform for prototyping. The underlying OS allows for full access to all of the device's technologies.
MediaSmart Server http://www.hp.com/united-states/campaigns/mediasmart-server/?jumpid=re_r602_crosslink/ts_alt/mss/home	Header-less small form factor PC which operates as an intelligent NAS within a consumer's home.	Provides presence in the home which can be assumed to be always on and as such may be useful as some form of content and application cache and act as a stepping stone on our roadmap towards a fully cloud-based world.
MediaSmart Connect http://www.hp.com/united-states/campaigns/mediasmart-connect/?jumpid=re_r602_crosslink/ts_alt/msc/home	A set-top box form factor media player / media center extender using the same HP MediaSmart user interface as found previous on our MediaSmart TV range.	Although the product is coming to the end of its life the MediaSmart Connect offers us an convenient, short-term, means of presenting applications and services into a living room / TV environment, without requiring an entire PC.
HP Upline https://www.upline.com/	Provides online, secure storage, backup and access to files.	An example of a consumer cloud-based service operated within PSG. One of the only consumer service offerings that PSG operate (Snapfish is operated by IPG)