Re:Know Ecosystem Plan

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1 Introduction

One deliverable for the first funding period of the Re:Know project is a plan for building an ecosystem for commercializing the results of the project. This ecosystem plan is a result of work done in the project during the first funding period, especially in WP 4. In addition to a review of the current literature on business ecosystems, the plan is based on the analysis of ongoing trends in knowledge work, especially in the use of knowledge work tools. For this purpose, workshops with knowledge work organizations were arranged to understand the concrete needs of organizations and workers in addition to the ongoing trends. As we see it, an ecosystem based on the research results can also have roles that reach beyond acting as a *commercialization platform* for applications based on the research. By acting as a sort of a living laboratory in which the research can be performed and research outcomes tested in the wild, the ecosystem is also an important *part of the research* itself. More generally and perhaps most importantly, the ecosystem, particularly due to its openness, is also a *general enabler of knowledge work tools* by means of the shared resources it provides for the tool developers.

2 Open ecosystem

2.1 What is an open ecosystem?

In business literature, the ecosystem metaphor has gained popularity as a mean of describing complex networks of companies or other stakeholders. In particular, a "business ecosystem" refers to an interdependent and loosely interconnected network of companies or other economic actors. It is formed around core technologies or assets, and the network participants share the fate of the whole ecosystem (e.g. Iansiti & Levien 2004; Muegge 2013; Valkokari et al. 2014). The concept of "innovation ecosystem" is used in a similar fashion, though it may also refer more loosely to actors located in a certain geographic area, such as Silicon Valley (Valkokari et al. 2014). In this project, by ecosystems we refer to the core technology -enabled business ecosystems.

The ecosystem metaphor provides a strong image of the importance of the health of the ecosystem as a whole: individual companies thrive or suffer along with the ecosystem. Also, as in a biological ecosystem, the ecosystem participants are free to fulfill their own needs while being partly supported by the richness of the ecosystem.

Originally, the business ecosystem referred particularly to a company-centric ecosystem and from a strategy perspective (Moore 1993; Valkokari et al. 2014). In a company-centric ecosystem, the core technologies or assets – the core enablers of the ecosystem – are developed, controlled and actively managed by a central company (Iansiti & Levien 2004). Other actors in the ecosystem occupy niche positions that are enabled by the central company. These other actors are dependent on the central company through their use of resources provided by the core

enabler. The central company shares value with the ecosystem actors via the core enabler, but at the same time controlling the core enabler makes it possible for the company to include value capture mechanisms in the core.

As an example, in mobile software ecosystems the central companies are Apple, Google or Microsoft, the core enablers are the phone operating systems and app marketplaces that have built-in value capture mechanisms, and niche actors include app developers and related service providers.

In the Re:Know project, by contrast, we aim to seed an open ecosystem. An open ecosystem is also centred around core enablers, but they are not controlled by any single company or other actor. In this case, core enablers are shared resources – such as standards – that are managed collaboratively. Functioning of the ecosystem is not dependent on a single company or actor, and participation in the ecosystem is open. Roles enabled by an open ecosystem are flexible, and some actors may play coordinating roles in the development of the core enabler. The process for technology and policy development is freely accessible for all participants. Since no single actor controls the core enablers, the value capture mechanisms are not tied to them either; all actors have their own business logic that is built on top of the shared resources. An existing example of an open ecosystem is the internet, where the core enablers are the basic communication standards, addresses and top-level domain names. Central concepts related to business ecosystems and key differences between company-centric ecosystems and open ecosystems are summarized in Table 1.

Business ecosystem are often described (Moore 1993) and visualized (e.g. Heikkilä & Kuivaniemi 2012) as consisting of layers that correspond to levels of commitment to the business. In a company-centric ecosystem, the central company's core business would be put in the center, the next layer would consist of the extended enterprise including e.g. complementors, some suppliers and standard-setting bodies, and the outer layer would consist of e.g. research bodies and investors.

In an open ecosystem, similar layers could be imagined from each company's perspective, but unlike in the case of a company-centric ecosystem, the whole ecosystem could not be described in a meaningful way from this perspective. Instead, more relevant layers can be described when the open core enabler of the ecosystem is placed in the center, the implementation of the core infrastructure and corresponding actors are at the next layer, and the beneficiaries of the ecosystem (companies making use of the core infrastructure and end-users) are at the outer layer (see Figure 1).

This description of the ecosystems shows a significant difference in company-centric and open ecosystem. In the company-centric case, most of the value in the ecosystem is captured in or near the central layer. In an the open ecosystem, most value is captured in the outmost layer, that is, by the ecosystem participants; and very little or no value is captured in the core enabler.

Table 1. *Comparison of open and company-centric ecosystems*

	Open ecosystem	**Company-centric ecosystem**
Core enablers Ecosystem has some core components or enablers that form the basis of the ecosystem. These can be technologies and assets that the ecosystem participants use to develop products and services. For the core enablers to have significance, they have to provide solutions to problems shared by many ecosystem participants and to make specialization possible.	The core enablers are open in the sense that they are not controlled by any single actor. Core enablers are shared resources such as specifications or standards that are managed collaboratively among the participants. ***In the Internet ecosystem*** *core enablers are basic communication standards, addresses (IPv4 and IPv6) and top-level domain names (.com, .org, country codes, etc.).*	The core enablers are assets or technologies that form a platform that is controlled by the central company. The ecosystem is formed of economic actors that are anchored to the platform. ***In mobile software ecosystems*** *the phone operating systems (iOS, Android, Windows) and marketplaces (App Store, Google play, Windows Phone Store) are core enablers.*
Roles Business ecosystem is an interdependent and **loosely interconnected** network of actors whose individual success is dependent on the outcome of the whole network (Iansiti & Levien 2004). In other words, the members share the fate of the whole ecosystem. The participants of the ecosystem can specialize in different roles, some of which are more central and some more peripheral in the network.	Functioning of the open ecosystem is not dependent on any single actor and participation to the ecosystem is open for all. Some organizations can choose to play **coordinating roles** in the development of the core enablers and others may take more niche roles by making use of the ecosystem resources. The process for technology and policy development is freely accessible for all participants. *Organizations like W3C (web standards) and ICANN (Internet's naming system) have coordinating role in development of enabling standards and policies.*	The central companies occupy **hub positions**. They have an interest to keep the ecosystem healthy, and they actively manage the ecosystem by managing the core enabler (Iansiti & Levien 2004). The **niche players** specialize in roles that are enabled by the platform and, in essence, the existence of which is dependent on the central company. The conditions of participation in the ecosystem are decided by the central company. *Google, Apple and Microsoft are keystone firms while the phone manufacturers and application developers are niche players.*
Value creation and value capture The ecosystem participants use shared resources provided by the core enabler to create value. The shared resources enable the players to concentrate their own resources in creating value by complementary products and services. The ecosystem participants also have mechanisms to capture some of the created value. The value capture mechanism can be built directly into the core enabler of the ecosystem or on top of that.	Since no single actor controls the core enablers, the value capture mechanisms can not be tied to them either. Different actors have their own business logic that is build on top of the shared resources. Many companies have strongly internet based business models, but the core standards, addresses, domain names are not tied to value capture mechanisms.	Control of the platform makes it possible for the keystone firm to build a value capture and value sharing mechanisms in it. Most of the value in the ecosystem is created by the niche players. A key strategic decision for the keystone player is to find a balance between value capture and value creation. *Google, Apple and Microsoft share value by enabling access to the users of the operating system, capture value and provide others means for value capture in the market places.*

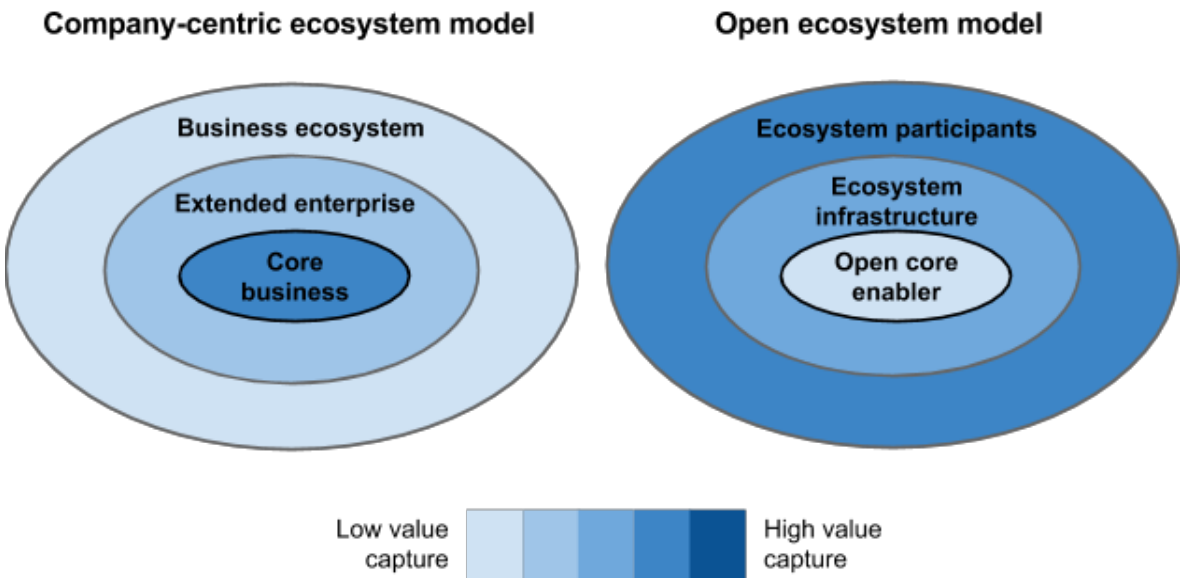


Figure 1. *Company-centric and open ecosystem models.*

2.2 Benefits of an open ecosystem

The benefits of an open ecosystem arise from the open nature of the core enabler. The core enabler of an open ecosystem is shared infrastructure. While a specific implementation of the core infrastructure may be more or less open, alternative implementations of the core enabler are always possible, and no single actor can fully monopolize the core enabler.

Therefore, participation in an open ecosystem is by nature unrestricted. Any interested parties can develop realizations of the core enabler and start developing niche services that make use of the core enabler. Even though participation in a single service built on the ecosystem core may be subject to someone's approval, there are no restrictions on developing alternative services.

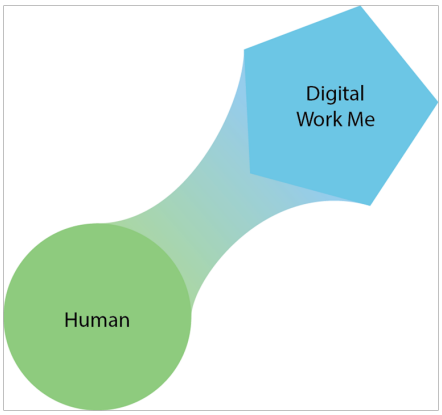
In an open ecosystem, roles for ecosystem participants are not fixed or predetermined. Innovation, flexibility and evolution regarding roles is possible. Allocation of roles is not subject to approval or judgement of any party. As the value capture mechanisms are not built in to the core enabler, an open ecosystem makes various business models possible and enables freedom in business model innovation.

3 The Re:Know ecosystem

3.1 Digital Work Me

For the purpose of focusing and directing our research of knowledge work tools, we mapped the major ongoing trends of knowledge work. These trends give rise to relevant, actionable needs of knowledge workers and knowledge work organizations. The most central observation from the

trends and needs analysis was that the organisation of the work and ways of working are becoming increasingly diverse and complex. The constant factor amidst this tide of change is the human, the individual knowledge worker. Hence, instead of focusing on the work organizations, we place the knowledge worker at the center. The aim of our knowledge work tool development, then, is to support the knowledge worker's efficiency and wellbeing in various knowledge work tasks related to information seeking and sense-making. These tasks can take place in individual and collaborative work situations and across e.g. geographical and organizational boundaries.



In our view, these objectives can only be accomplished by employing diverse contextual information gathered from multitude of sources. For this purpose, we have developed the concept of **Digital Work Me**, which is an interoperable, device-independent and cloud-integrated data account. On a practical level, from the user's point of view, the Digital Work Me compares to an account, such as an email account. The Digital Work Me provides storage for data, standardized access to this storage and the means to manage the access rights. Functionally, however, it goes far beyond being a data account; it is an intelligent, personal computational platform that aggregates personal data from various information sources and contexts, processes this information, creates an index of context and time, and generates higher-level profile derivatives, such as information about the worker's cognitive state and preferences. On top of being a data repository, it is an intelligent agent interface able to provide the necessary information while protecting the worker's privacy and the data's confidentiality.

Tools that interact with the Digital Work Me can generally be data users or data loggers; they can provide services that use the data Digital Work Me already contains or push new data to Digital Work Me (see Figure 2). The tools can, for example, employ rich personal activity histories contained in the Digital Work Me in order to provide contextual recommendations or search results. Other tools could include e.g. services for context interpretation based on sensors or other external data sources, discussion and event loggers or Digital Work Me -based profile matching services. The concrete types of data stored in the Digital Work Me are not pre-determined and depend on the particular tool. The overall aim is that data that has reuse value can be stored in Digital Work Me.

The Digital Work Me account puts knowledge workers at the center of their own data, as they have access and full control to the data stored in their Digital Work Me. The knowledge workers choose when data is stored, who can see the Digital Work Me, who can access the data it contains and when the data can be accessed. Other knowledge workers, other instances of Digital Work Me and different kinds of tools and services can interact only with the data they have a right to access. Through the Digital Work Me, then, a worker can manage the information flows between different knowledge work applications and interoperate across physical, organisational and

temporal boundaries. The personal Digital Work Me account gives its user the control over their own data, affording better application transparency and privacy. The basic view is that the worker decides about his own Digital Work Me, managing access rights and sharing policies for different applications. Naturally also the work organisations may impose sharing policies on its employees.

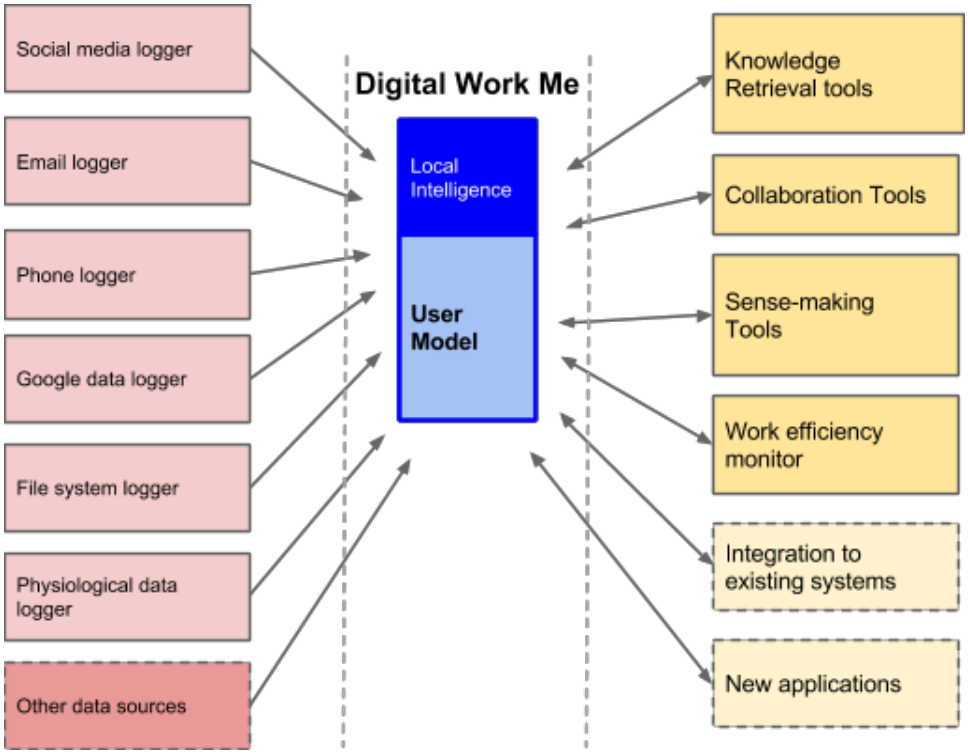


Figure 2. *Example of basic tools connecting with the Digital Work Me account system. Data logger tools are on the left side, data user tools on the right side.*

The contextual information that can be stored in the Digital Work Me can be used by various different services. Only some exemplary service can be feasibly implemented in this research project. Therefore, the Digital Work Me concept spans contexts much wider than the Re:Know project. To make the full use of the Digital Work Me concept, we aim to realize and open ecosystem around the Digital Work me – in other words, promote it as the core enabler of an open ecosystem.

3.2 Core enabler of the ecosystem

The Digital Work Me is not only a single service implemented by a research project. Instead, it is an open standard that will be initially developed in the project. This means that when the standard is available, anyone can develop applications that employ the Digital Work Me interfaces for data storage and retrieval, provide end users with Digital Work Me accounts, or implement server-side Digital Work Me account systems or control and management interfaces

for end-users. Interested parties can also participate in the further development of the Digital Work Me standard.

A point of comparison for the Digital Work Me in this role could be the email system. Email is a set of communications standards, according to which different actors have developed server and client side software infrastructure. Basically anyone, including large commercial providers and private persons, can set up an email server and start providing email account services. And email is interoperable in the sense that software once developed can be used to access the email account services of various account providers. All of these qualities are valid for the Digital Work Me system also, though the services that can be provided with the system reach far beyond what can be done with email.

The Digital Work Me, then, is a core enabler of an ecosystem that provides specialization opportunities for different kinds of data users, data loggers and account providers. The shared value created by the core enabler is standardized access to data, and actors in the ecosystem create additional value by taking advantage of the core enabler.

A central feature of our plan for the open ecosystem is that specific roles in the ecosystem, types of data that can be logged or services that can be provided by using the data are not predefined or restricted by the Digital Work Me concept. Specialization opportunities, then, are not limited to specific roles or to the provision of certain types of tools or services.

The Digital Work Me operates as an enabler on three levels. On a *conceptual level* it enables the fulfilling of various needs of future knowledge workers and work organizations. On a *technical level* it provides interoperability between various data users and data loggers, enabling the creation of tools and services depending on data and providing use and reuse opportunities for gathered data. On a *business level* it is a core enabler and a shared resource of an open ecosystem that enables specialization and value creation by the actors in the ecosystem.

3.3 Ecosystem roles for external participants

A key appeal of the ecosystem model is that the shared ecosystem resources provide the participants with opportunities to specialize in their own roles. In the Digital Work Me ecosystem, we foresee at least the following roles enabled by the ecosystem: different kinds of account operators, application developers providing both data loggers and tools that use the data, and basic infrastructure providers. Some aspects of these ecosystem roles - including exemplary business models - are described below. Importantly, as the Digital Work Me ecosystem is open, these roles are in no way not fixed - nothing limits the actors from taking other roles or from freely combining the roles to suit their own business logic.

Table 2. *Digital Work Me operators*

Who	**Purpose**	**Value for ecosystem**	**Benefit from ecosystem**	**Revenue source**
Work organisation	Provides accounts for employees	Users for tools and services	Account system, tools that add value for workers	
Cooperative	Provides accounts for e.g. freelancers	Users for tools and services	Account system, tools that add value for members	Membership fees, sales of data
Companies	Provides accounts as SaaS	Users for tools and services	Account system, tools that add value for customers	Sales of accounts, sales of data products

Table 3. *Digital Work Me application developers*

Who	**Purpose**	**Value for ecosystem**	**Benefit from ecosystem**	**Revenue source**
Data logger provider	Collects data, stores data in accounts	Collect data and make data available	Standardized storage, access controls, users and uses for data	Sales/licensing of logger hardware, software, and logging services
Application provider	Provides tools and services that use data	Add value by providing uses for data stored in accounts	Standardized source of data and access controls, users for apps	Sales/licensing of software, services and hardware
Data aggregator	Collects data from accounts and provides data aggregates	Intermediary between account users and data aggregate users	Standardized source of data and access controls for data	Sales of data aggregates

Table 4. *Digital Work Me infrastructure providers*

Who	**Purpose**	**Value for ecosystem**	**Benefit from ecosystem**	**Revenue source**
Server-side software developer	Provides server software for account operators	Enable account provider infrastructure	Account system specifications, users for software	Typical (open source) business models
Client-side software developer	Provides client software for account users	Enable end-user infrastructure	Account system specifications, users for software	Typical (open source) business models

As described above, different actors can employ various business models, and their core activities may comprise of sales of services, data, hardware or software. Possible products and services enabled by the Digital Work Me ecosystem can be segmented as follows:

- Mobile applications: Development of apps using the shared resources of the Digital Work Me ecosystem. Companies providing apps are typically small start-up companies.
- Web services: Solutions based on Digital Work Me resources can also be built on standard web interfaces. These can then be run on desktops, laptops, tablets and also mobiles. Different kinds of internet companies – established companies or start-ups – can provide these applications and services.
- Auxiliary devices: While some Digital Work Me data loggers can be implemented as applications for e.g. smartphones, also auxiliary devices are necessary for gathering contextual information. Devices can also be used for processing data or for interaction with data. Companies involved in this segment are producers of sensors, devices and software.
- Consultancy services: Different kinds of organisations and end-users have different kinds of data and different needs for Digital Work Me enabled services. This means solutions can be tailored and companies given advice on how to optimally utilise Digital Work Me. The revenues can come from consultancy, deployment and development work.

3.4 Benefits of open Digital Work Me ecosystem

The Digital Work Me ecosystem provides a solution to the fragmentation of personal data, which caused by the data's existence within various non-interoperable services. This is achieved by making the worker's personal data accessible for ecosystem participants in a way that access to data is not restricted by a central company. The workers themselves are the gatekeepers of the data, deciding on giving access to their data based on the additional value that is expected from the use of the data.

Data created and stored by one application can be reused by other applications. This allows small players (for example, startups or research institutions) to gain access to a user's personal data that can be much more complete than what is usually available for them.

In the Digital Work Me ecosystem, processes related to the users' personal data are transparent. Data collection, uses of data, and visibility of data to other users and applications are subject to the user's decisions. The uses of a user's personal data by tools and applications are trackable and controllable.

The use of Digital Work Me services are not inherently conditional to the use of one provider's software or hardware. On the contrary, the core enabler is designed in a way that enables developing tools that make it possible to use different devices and platforms.

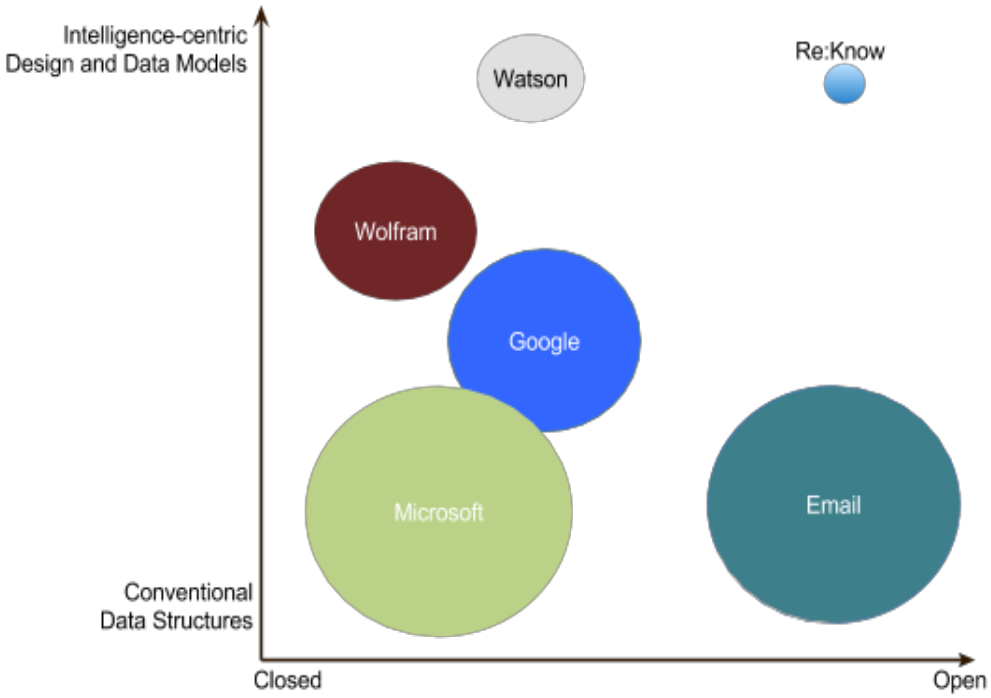


Figure 3. *Comparison of knowledge work environments in terms of openness and intelligence centricity. Sizes of the bubbles roughly indicate the importance of the respective environments in knowledge work currently, so that a bigger bubble indicates higher importance.*

Tools, applications, methods and software developed for research purposes can be shared, distributed and (when relevant) commercialized via the open ecosystem. This allows the users in general and society overall to benefit from results of academic research in a way that may not be possible in the context of current knowledge work tools and personal data paradigms.

Unprecedented user data can be made available for research purposes via the ecosystem. This can be made possible via tools that collect data from many users, anonymize it and provide aggregated and anonymized data for researchers. Any such data collection is conditional on the users' permission.

Figure 3 shows how the knowledge work environment based on the Digital Work Me concept is compares to other environments in terms of openness and intelligence centricity. Other open knowledge work environments exist, as well as other intelligence-centric ones. The combination of the two makes the Re:Know environment uniquely positioned.

4 Ecosystem plan

4.1 Initial steps: seeding the ecosystem

To provide the seed for the open ecosystem, we will initially develop a specification for the Digital Work Me account system. This specification includes a set of concrete APIs for data input and output. As needed, also a library of standard functions will be developed. This specification will evolve during the project, and it will be worked into a Digital Work Me standard during the later parts of the project.

During the course of the project, we will develop pilot implementations of key ecosystem components: Digital Work Me account system, the end-user management interface and example applications that act as data loggers and that make use of the the data. These applications will be the first components in the Digital Work Me ecosystem and serve as exemplary pilot applications that use the ecosystem's shared resources.

In addition to developing the initial infrastructure and pilot applications, we will initiate a community of Digital Work Me account users. The first users will be account holders in our own pilot account system. In practice, the very first users will be members of our research organizations, but external users and also external organizational account providers will be taken on board in the early stages.

Priority is placed on implementing both pilot applications and pilot account systems in the wild as early as possible, to ensure that the Digital Work Me concepts and systems take the step out of the lab.

In summary, the purpose of the ecosystem seeding activities is to facilitate the emergence of and participation in the Digital Work Me ecosystem by

- Making the ecosystem core available both conceptually and concretely;
- Setting up an account system for Digital Work Me accounts;
- Providing the pilot applications for the ecosystem; and
- Creating the initial user base for the ecosystem.

These seeding activities create the first components of the Digital Work Me ecosystem – they act as pilots for and make use of the different aspects of the ecosystem core technology and concepts. In addition to this seeding activity, we will also start building the actual ecosystem by facilitating and encouraging participation by different kinds of external actors.

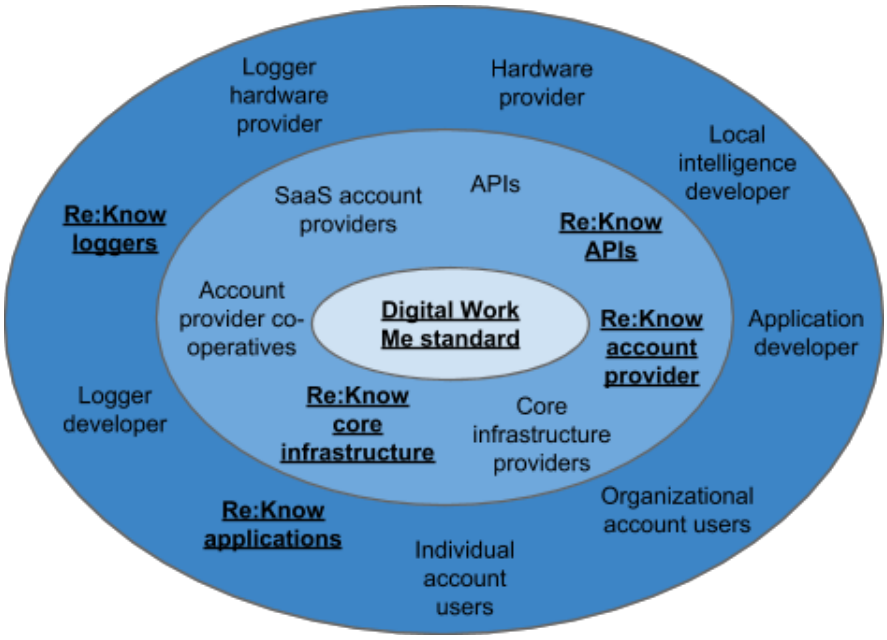


Figure 4. *The open Digital Work Me ecosystem. Parts of the ecosystem are realized in the Re:know project (underlined), other parts are enabled by the ecosystem and realized by other ecosystem participants.*

4.2 Further steps: supporting the ecosystem

The project will function as an incubation activity for the ecosystem, but it is critical that pre-commercial activity is performed by multiple organizations early on during the project, and before the end of the project there will also be commercial activity. To support the formation of an ecosystem around the Digital Work Me core and the take-up of the abovementioned ecosystem roles we will take the following actions that go beyond the ecosystem seeding activities:

- We arrange ecosystem events oriented primarily for the business community. These events serve both as dissemination events and as feedback collection opportunities. The project will organise annually larger stakeholder events and smaller focused events for specific ecosystem roles.
- Focused events include competitions or hackathons around the Digital Work Me core. Such an event could, for example, take the form of a benchmarking scenario where external teams are asked to replace a specified part of the system. In addition to furthering research and collaboration around the topic, such events also serve to increase community awareness of the ecosystem and its possibilities.
- To initiate new business opportunities within existing companies and for new start-ups, we develop easily adoptable business models around Digital Work Me. Business models

are developed for different kinds of potential ecosystem actors and disseminated to both academic and public audiences..

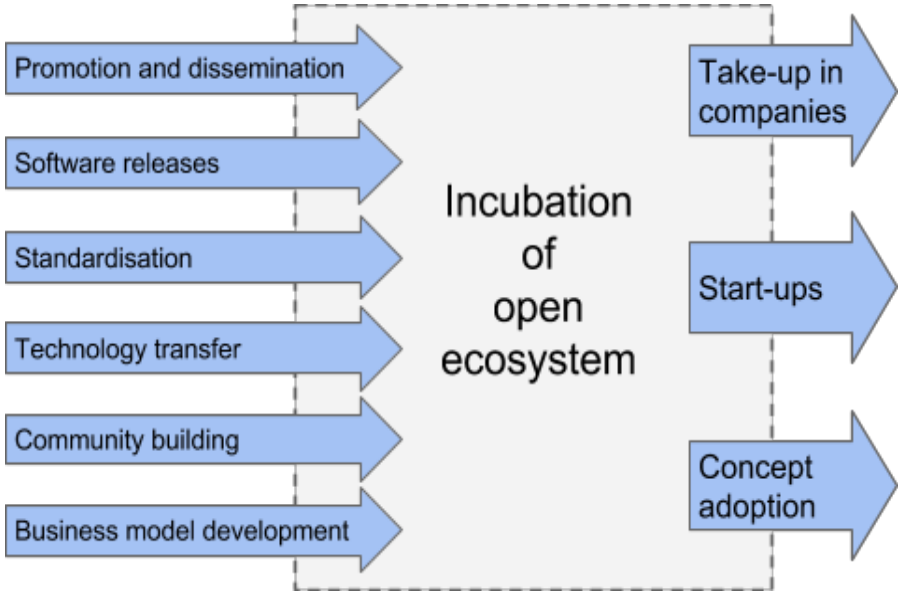


Figure 5. *Paths to business in the Re:Know project.*

The number of Digital Work Me accounts is directly related to how appealing the ecosystem is for new organizations to engage in and start developing applications for. Thus, building a community of end-users for the ecosystem is an important part of ecosystem building. Another rationale for end-user community is to create a living lab of real data accounts that the project itself can make use of.

- As part of the end-user community building, events targeted to individuals will be arranged to attract people to start using Digital Work Me accounts.
- In order to enable significant Digital Work Me adoption it is important that different organizations, and not only individuals, adopt the model. This is done by developing pilot Digital Work Me operator models, as well as attracting existing users to adopt new operator models.

The ecosystem is also naturally promoted through more typical outreach activities such as videos, interaction with the press, publications and online presence. Paths to business are described in the figure below, where the project's activities are directed so that they support the incubation of an open ecosystem based on the Digital Work Me concept. Take-up of the the Digital Work Me system and Re:Know tools in companies, formation of new start-ups and generally the adoption of the project's concepts are enabled and supported by the ecosystem.

4.3 Milestones and deliverables for ecosystem building

In addition to numerous other results and deliverables to be produced during the project, the following ecosystem-related milestones and deliverables have been specified in the project plan:

Digital Work Me specification and standard

The initial Digital Work Me specification, a higher level document specifying the requirements for the system, will be released in Fall 2015. After this, new releases will be continuous as the specification evolves towards a working standard in the later parts of the project.

Account system

The initial versions of concrete software APIs i) for implementing loggers for inputting new information to the Digital Work Me system and ii) for accessing the information stored in the system will be released in Fall 2015. A control interfaces for end-users will be published and a Digital Work Me operator will be established in Spring 2016.

The relevant parts of the account system will see continuous new releases as the system evolves during the project.

Accounts

In our view, the number of Digital Work Me accounts is directly related to how appealing the Digital Work Me ecosystem is for new organizations to engage in and start developing for. Significant adoption of Digital Work Me accounts is a key contributor to the growth of the whole ecosystem. Therefore, we aim at exponential growth in the number of Digital Work Me accounts during the project. Initially, in Spring 2016, when a Digital Work Me operator is established, we expect to have 100 Digital Work Me accounts. During the project, we expect exponential growth in the number of accounts with 10 000 accounts in four years.

Data logger tools and data user applications

Initial data logger applications will be developed in the early stages of the project, including the first release of a data logger in Fall 2015.

Several working tools for data logging and applications that use the data stored in Digital Work Me will be released during the project. These will include tools for contextual search, information retrieval and sense-making (either for individual or collaborative work situations) and also well-being related applications.

Ecosystem events

When the account system is released in Spring 2016, we plan to accompany it with a business modeling clinic for prospective ecosystem participants. An event promoting the account system will be organized for the public. A second such event for the public will be organized in Fall 2016. Towards the end of the project, we will organize a Digital Work Me benchmarking competition.

In addition to these events that are already concretely planned, regular other stakeholder events will be organized during the project.

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A huge amount of information is spread out in various data silos. The current systems and search engines have inflexible views to the data and they have only a limited ability to study the large data masses, leaving knowledge workers trapped in individual information bubbles. Current systems constrain the work instead of supporting the combined potential of human creativity and the capability of computers to handle big data.

We combine the multidisciplinary world-class expertise in machine learning, human-computer interaction, distributed computing, cognitive neuroergonomics and human factors at work, available within Helsinki Institute for Information Technology HIIT and the Finnish Institute of Occupational Health. Our objective is to develop Symbiotic Human-Information Interfaces, which pave the way for a revolution of knowledge work.

Symbiotic Human-Information Interfaces combine heterogeneous data sources and utilize the context of use and user actions to jointly with the user determine what information is most likely relevant, and provide the user with a new type of interactive and proactive interface to the data. In the context of knowledge work, we use our know-how on both computational principles and how humans process information to develop a new information management and utilization paradigm, enabling humans and computers to support each other optimally. Symbiotic Human-Information Interfaces will revolutionize information seeking and further cultivation into new knowledge.