

Pervasive Socio-Technical Fabric

The Next Generation Pervasive Systems Research Agenda

*fet*¹¹

Budapest, May 4-6, 2011

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20 years back ...

*“The most profound technologies are those that **disappear**. They weave themselves into the fabric of everyday life until they are **indistinguishable** from it”*

*“...each person is continually interacting with hundreds of **nearby interconnected computers** **without explicitly attending to them**”*



Mark Weiser:
"The Computer for the 21st Century",
Scientific American,
Vol. 265 No.9, pp. 66-75, 1991.

Pervasive Computing

Ubiquitous Computing

(Mark Weiser, Xerox PARC 1988)

Calm Computing

(John Brown, Xerox PARC 1996)

Universal Computing

(James Landay, Berkeley 1998)

Invisible Computing

(G. Borriello, UoWashington 1999)

Pervasive Computing

(Academia, Industry 1999, 2000)

Context Based Computing

(Berkeley/IBM 1999)

Hidden Computing

(Toshiba 1999)

Post PC Computing

(common sense)

The Disappearing Computer

(European Commission, FP5)

Ambient Intelligence

(European Commission, FP5)

Everyday Computing

(Georgia Tech, 2000)

Sentient Computing

(AT&T, 2002)

Autonomous Computing

(IBM, 2002)

Amorphous Computing

(DARPA, 2002)

Spray Computing

(Zambonelli, 2003)

...

Generation 1: **Connected**

Connecting literally every-“thing” to every-“thing”

driven by the availability of “technology to connect” (Internet, Mobile Data, Wireless Communic.)
(**Connectedness**, 1991-2005). >> **Networks of ICT systems**

- **clouds of communicating, miniaturized, cheap, fast, powerful, wirelessly connected, “always on” systems** (**omnipresent / total connectivity**)
- enabled by the **massive availability** of **miniaturized** computing, storage, communication, and embedded systems technologies
- **special purpose** computing and information appliances, spontaneously communicating
- **sensors** collect data, passive interaction with environment; **actuators** control devices, can modify environment
- sensor-actuator systems invert role of interaction from human to machine (**implicit interaction**)
- **organism like** capabilities (self-configuration, self-healing, self-optimizing, self-protecting)

Generation 1: **Connected and Disappearing**

*“It seems like a paradox but it will soon become reality: **The rate at which computers disappear will be matched by the rate at which information technology will increasingly permeate our environments and determine our lives.**”*

(Streitz & Nixon, Comm. of the ACM, 2005)



Norbert Streitz
(Smart Future Initiative)

Invited Speaker in Session on
Pervasive Socio-Technical Fabric
fet 11, Budapest
May 5, 2011

*“No need to carry (computing) devices with us. It’s all there in the environment. Everything is available everywhere. **The world around us is the ,interface‘.**”*

Generation 2: **Aware**

Aware interaction among every-“thing”s

driven by upcoming context recognition and knowledge processing technologies
(**Awareness**, 2000-2007). >> **Ecologies of ICT systems**

- situation aware, **self-aware**, **context-aware**, energy-aware, etc.
- reframing autonomy to be **based on “knowledge”**, extracted from low level sensor data captured in a particular situation or over long periods of time
- “autonomic elements” able to **capture. interpret, predict, context** (from sensors)
- to build up, represent, carry and share **knowledge**
- to **self-describe**, -manage, and –organize with respect to the environment
- behaviour >> **“knowledge based” monitoring, analyzing, planning and executing**
- interaction in **spontaneous** spatial/temporal contexts, based on proximity, priority, privileges, capabilities, interests, offerings, environmental conditions, etc.

Generation 2: **Aware**

“... Masses of networked sensor-equipped computing devices are **overcoming longstanding temporal and spatial boundaries to human perception ...**”

“...**Ethics** and values **are becoming the central design material** of this century...”

“... by the middle of the century the **boundaries** between ‘real’ and ‘virtual’ or ‘augmented’ **perception will become blurred ...**”



Albrecht Schmidt
(University of Stuttgart)

Invited Speaker in Session on
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Generation 3: **Meaning**

Meaningful interaction of every-“thing”s within a complex system

build upon connectedness and awareness, but give **meaning to situations / actions**

(**Meaning**, 2009 –)

- use technical sensors (aligned with 5 human senses, + 0.5 from mobile phone, J. Pitt) for vision, audition, gustation, olfaction, tactition to **give meaning to situations**
- **computational perception** (EEG, ECG, EOG, ..) > to **extract meaning ...**
- understanding **patterns** (activity, mobility, „life style“) > to **extract meaning ...**
- **formalization of human cognitive capabilities: attention, intent, emotions, experience, ...**
- **relate meaning to building up belief, acting, expectation, memorizing, learning, developing behaviour, building up knowledge**

Generation 3: **Meaning**

*“... How do we build pervasive systems that developers take pride in, that consumers aspire to own and that children look forward to inheriting ? **Is quality fundamentally at odds with ubiquity ?..**”*



Nigel Davies
(Lancaster University)

Invited Speaker in Session on
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”Socio-Technical Fabric”

Highly complex, orchestrated, cooperative and coordinated systems

- “Ensembles of Digital Artefacts” (FP7 FET)
- “the power of crowds”
- *“... **dynamic** network of many ... acting in parallel ...”*
*“... constantly **acting** and **reacting** to what the other are doing ...”*
*“... where the **control** tends to be highly **dispersed** and decentralized ...”*
*“... if there is to be any coherent behavior, it has to arise from **competition** / **cooperation**.”*
*“... overall behavior of the system is the result of a huge number of decisions made **every moment** by many individuals ...”* (Castellani, B., Haerty, F.W., 2009).
- **deployment of pervasive computing systems at massive scale**
poses challenges both in the technological as well as in the societal dimension!

10^{12} - 10^{13} “things” or “goods” traded in markets

10^9 humans; 10^9 nodes on the internet, mobile phones, cars, digital cameras, etc. on planet

10^7 citizens in megacities

10^8 users on Facebook, 10^8 videos on YouTube, 10^7 titles on last.fm, ...

”Socio-Technical Fabric”

“*Pervasive Computing* has woven in the fabric of everyday life of users. *Pervasive Computing* **now weaves in the fabric of everyday life of society!**”

“... a *curious inversion* where *public* turns *private*, and **individualism** is **absorbed by the masses** ...”

“You cannot **NOT interact!**”



Alois Ferscha
(University of Linz)

Organizer of Session on
Pervasive Socio-Technical Fabric
fet 11, Budapest
May 5, 2011

Presentation



Norbert Streit
(Smart Future Initiative)

Invited Speaker in Session on
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Albrecht Schmidt
(University of Stuttgart)

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May 5, 2011

The PerAda Research Agenda Book

Pervasive Adaptation

The Next Generation Pervasive Computing Research Agenda

A book by *Th. Sc. Community*

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Research Agenda

for Future and Emerging Technologies

A book by *Th. Sc. Community*

last change 2010-02-18, v1.61

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Research Agenda » New Contribution

Title:

Author: Michael Matscheko

Point of View: Academia (default)

Chapter: Autonomous Adaptation (default)

Keywords:

Duration: short term (<1 year) (default)

Importance: pragmatic (default)

Original Contribution:
Insert your text here.

We recommend to write the contribution offline and copy/paste your text here, to avoid any data loss during the transmission process.

Formatting guidelines:
Only plain text (no bold, italic, etc. text).
It is allowed to insert hyperlinks, but we urge you to only add references at the end of your text, as shown in the example below. Do not add more than 8 References. Make sure you specify a full URL, including the protocol (e.g. http://...)

References:
My Paper, http://example.org

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Research Agenda » Contribution: Adaptive Automations for Pervasive Services

Title: Adaptive Automations for Pervasive Services

Author: Anthony Savidis, profile

Point of View: Academia

Chapter: Autonomous Adaptation

Keywords: adaptation, services, composition, automation, knowledge

Agreement: medium (0)

Duration: long term (>3 years)

Importance: challenging (15)

Original Contribution:

In pervasive computing we face a rapidly evolving spectrum of an increasing number of services available to anyone, at anyplace, anytime. In everyday life, the average time spent in using such pervasive services ranges from tens of seconds to a few minutes, while they are involved in a growing number of daily, weekly or monthly activities. Clearly, the diversity of platforms, services, tasks and interactions styles introduce serious usability challenges. Moreover, for users involved in such situations, not only speed and accuracy are crucial, but all potential delays accumulate to the rest of people waiting at the same service point. In such sessions, a considerable amount of time is spent by users to repeat sequences of steps for performing the same tasks across independent sessions, such as choosing preferred operations and inputting all required parameters. In this context, adaptive automation is considered a critical element of pervasive adaptation, combining adaptive interaction, adaptive composition, and task automation, by involving knowledge regarding user profile, intentions, point of use, and past use sessions.

It is believed that the ability to record activity traces, recognise patterns of use, identify personal habits, detect repeated tasks, and adaptively apply automations will play a key role towards the broad acceptance and proliferation of pervasive services in the near future. Due to the huge growth of the end-user population, traditional centralised processing and storage approaches regarding user-oriented information may become impractical, even unethical, putting forward the need for personal processing and knowledge resources. While such living, evolving, and personal memory can support advanced future pervasive adaptations, issues such privacy and security become more prominent than ever.

Challenges: privacy prevention, service composition, interface adaptation, task automation, session traces, activity patterns, habits recognition, personalized processing, personal memory.

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Research Agenda » Contribution: Adaptive Automations for Pervasive Services

Title: Adaptive Automations for Pervasive Services

Author: Anthony Savidis, profile

Point of View: Academia

Chapter: Autonomous Adaptation

Keywords: adaptation, services, composition, automation, knowledge

Agreement: medium (0)

Agreement

The agreement value indicates how much others agree with the presented topic.

Each registered user is allowed to vote and increase this value by the following amount:

strongly agree	+2
agree	+1
disagree	-1
strongly disagree	-2

New contributions starts out with a value of zero. Each spectrum of an increasing number of services available to anyone, at a number of daily, weekly or monthly activities. Clearly, the diversity of services will lead to serious usability challenges. Moreover, for users involved in such activities, the amount of time is spent by users to repeat sequences of steps for operations, such as choosing preferred operations and inputting all required information, is considered a critical element of pervasive adaptation, combining adaptive user profiles with past use sessions.

It is believed that the ability to record activity traces, recognise patterns of use, identify personal habits, detect repeated tasks, and adaptively apply automations will play a key role towards the broad acceptance and proliferation of pervasive services in the near future. Due to the huge growth of the end-user population, traditional centralised processing and storage approaches regarding user-oriented information may become impractical, even unethical, putting forward the need for personal processing and knowledge resources. While such living, evolving, and personal memory can support advanced future pervasive adaptations, issues such privacy and security become more prominent than ever.

Challenges: privacy prevention, service composition, interface adaptation, task automation, session traces, activity patterns, habits recognition, personalized processing, personal memory.

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Research Agenda » Contribution: Adaptive Automations for Pervasive Services

Adaptive Automations for Pervasive Services

Anthony Savidis, profile

Academia

Autonomous Adaptation

Adaptation, services, composition, automation, knowledge

Medium (0)

Long term (>3 years)

Challenging (15)

Contribution:

During the last few years we face a rapidly evolving spectrum of an increasing number of services available to anyone, at any time and in any place. In everyday life, the average time spent in using such pervasive services ranges from tens of seconds to minutes. Clearly, the diversity of tasks and interactions styles introduce serious usability challenges. Moreover, for users involved in such sessions, a considerable amount of time is spent by users to repeat sequences of steps for the same tasks across independent sessions, such as choosing preferred operations and inputting all required context, adaptive automation is considered a critical element of pervasive adaptation, combining adaptive composition, and task automation, by involving knowledge regarding user profile, intentions, point of use, and environment.

The ability to record activity traces, recognise patterns of use, identify personal habits, detect repeated tasks, and generate personalized automations will play a key role towards the broad acceptance and proliferation of pervasive services in the future. This is due to the huge growth of the end-user population, traditional centralized processing and storage approaches that require a lot of information may become impractical, even unethical, putting forward the need for personal processing and storage. While such living, evolving, and personal memory can support advanced future pervasive services, the need for such privacy and security become more prominent than ever.

Keywords: service composition, interface adaptation, task automation, session traces, activity patterns, personalized processing, personal memory.

2010

- Edit/Update

Title: "G..."

Author: Dar...

Point of View: Acc...

Chapter: Aut...

Keywords: ada...

Agreement: me...

Duration: lon...

Importance: imp...

Original Contribution:

One of the main features of pervasive services is the ability to adapt in an autonomous way, to differ from the traditional presence of channels, storage, energy, atoms, and so on. This can be understood as different environments and interactions.

While self-adaptation is a key feature of pervasive services on local interactions or in distributed environments, they have received little attention according to some applications. This is due to the lack of interest in solutions that can limit the operational effort and resources (need to limit the environment, need to be exempt from such requirements, need to ensure the sustainability of innovation).

The question now is: how to design working parameters related to the performance of pervasive services that are achievable in terms of resources, cost, and architecture. Pervasive computing architectures, maybe based on energy consumption while maintaining high performance, maybe based on resource consumption while maintaining high performance. A remarkable remark is that some of the most successful biological analogies to and/or in nature are organisms that have always been favored by evolution. In other words, they have turned their weaknesses into opportunities. Turning them into opportunities for future challenges ahead of us.

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Research Agenda » Contribution: Theoretical Foundations of Socio-Cognitive Systems

Title: Theoretical Foundations of Socio-Cognitive Systems

Author: [Jeremy Pitt, profile](#)

Point of View: Academia

Chapter: [Societies of Artefacts](#)

Keywords: social networks, social intelligence, agents

Agreement: medium (0)

Duration: long term (>3 years)

Importance: challenging (15)

DG09]. A successful outcome would serve to establish the logical and computational foundations of a common theoretical framework for the executable specification with respect to runtime "social services" provision, as a basis for performing secure and reliable service discovery, composition, optimization, adaptation and deletion.

References:

[DG09] M. Draief and A. Ganesh. Spread of epidemics and rumours with mobile agents. In European Consortium for Industrial Mathematics Symposium (ECMI 2008), page To appear, 2009.

[Dra06] M. Draief. Epidemic processes on complex networks. Physica A: Statistical Mechanics and its Applications, 363(1):120-131, 2006.

[PKSA06] J. Pitt, L. Kamara, M. Sergot, and A. Artikis. Voting in multi-agent systems. Computer Journal, 49(2):156-170, 2006.

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Comments:

[Michael Matscheko](#) on 4. Mar 2010 12:49:

Just wanted to try the "comment" feature...

regards, michael

Submit and save - Cancel

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Compose comments

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Vote on agreement and importance

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The screenshot displays the PANORAMA Research Agenda Book interface. On the left is a navigation menu with 'Research Agenda' highlighted. The main content area shows a page for 'Contribution: Theoretical Foundations of Socio-Cognitive Systems' by Jeremy Pitt. The page includes metadata such as 'Author: Jeremy Pitt, profile', 'Point of View: Academia', and 'Keywords: social networks, social intelligence, agents'. Below this is a paragraph of text and a 'References' section. At the bottom, there is a 'Comments' section with a text input field containing 'Just wanted to try the "comment" feature... regards, michael'. A green box highlights the 'Submit and save - Cancel' button, and a green arrow points to it from the text 'Contribute new comment' overlaid on the image. At the bottom right, there are radio buttons for 'strongly agree', 'agree', 'disagree', and 'strongly disagree', along with a green arrow icon.

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Research Agenda » Contribution: Theoretical Foundations of Socio-Cognitive Systems

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Author: Jeremy Pitt, profile

Point of View: Academia

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The screenshot shows the PANORAMA Research Agenda Book interface. On the left is a navigation menu with 'Research Agenda' highlighted. The main content area displays a statement titled 'Theoretical Foundations of Socio-Cognitive Systems' by Jeremy Pitt. Below the statement is a 'References' section and a 'Comments' section. A comment by Michael Matscheko is visible. At the bottom, there is a 'Submit and save' button and a green-bordered 'Add Comment - Edit/Update' button. A green arrow points from this button to the text 'Only editors are allowed to modify any statement'.

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Title: Theoretical Foundations of Socio-Cognitive Systems
Author: Jeremy Pitt, profile
Point of View: Academia
Chapter: Societies of Artefacts
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Author: Anthony Savidis, profile

Point of View: Academia

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Keywords: adaptation, services, composition, automation, knowledge

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Duration: long term (>3 years)

Importance: challenging (15)

Original Contribution:

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Challenges: privacy prevention, service composition, interface adaptation, task automation, session traces, activity patterns, habits recognition, personalized processing, personal memory.

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Comments:
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Agreement and Importance
may change due to
user votings

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Autonomous Adaptation	Future Living Environment	Gordon Cheng
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Societies of Artefacts	Content and Communication without the Internet	Roger M. Whitaker and Stuart M. Allen
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Sociotechnical Systems	Transformation of society and the self in the digital age	Adrian David Cheok
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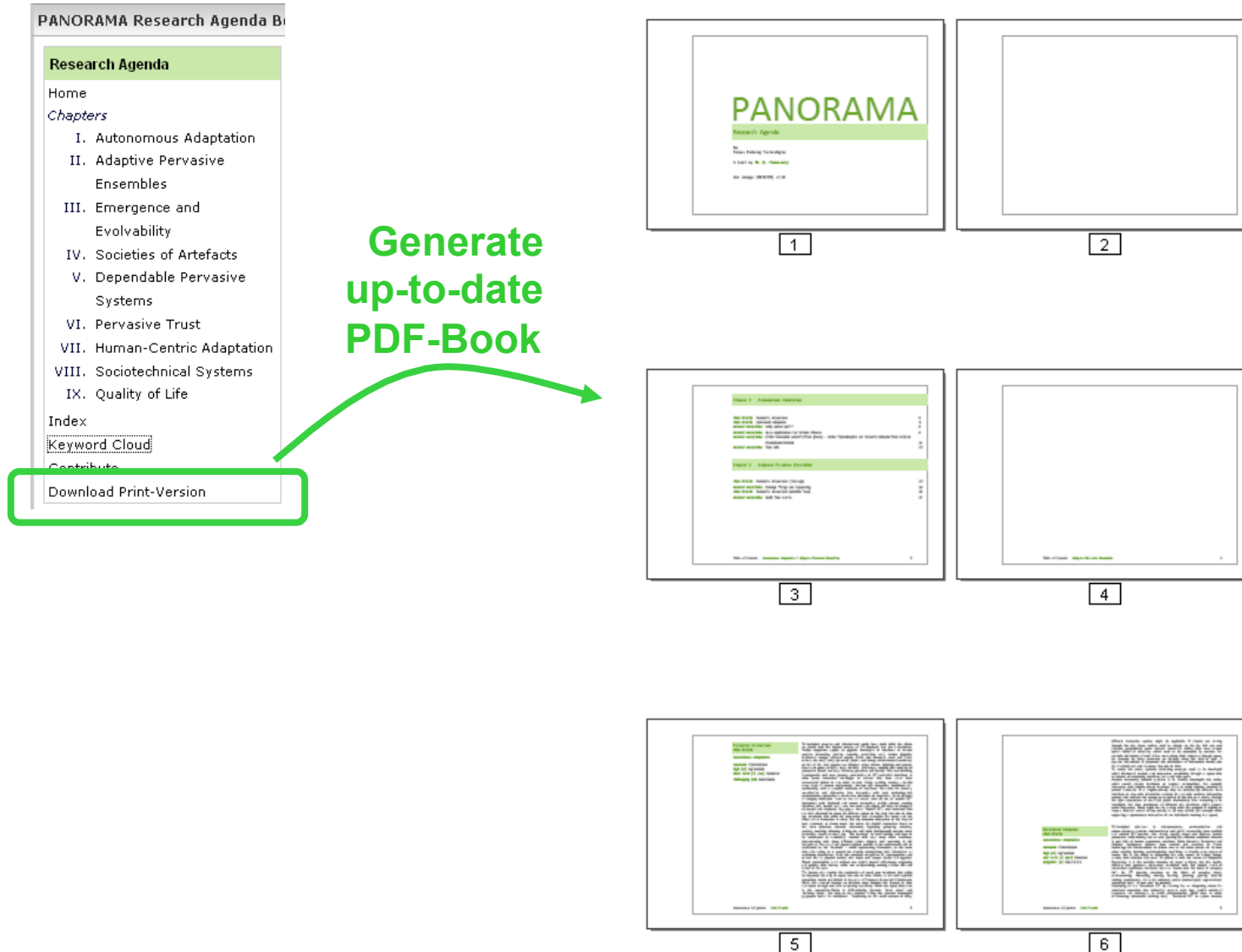
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Keyword Cloud

ad-hoc networks adaptation affective agent-based SOA agents architecture
argumentation Assistive technologies automation autonomous systems
autonomous vehicles bio-hybrid systems bottom-up design business models
business process modeling cloud computing cognitive collective adaptation
collective intelligence complexification composition computational intelligence
conceptual model context aware control convergence time cooperative systems
coordination models culture modeling culture trends data mining data stream algorithms
decisional privacy dependability deployment design development digital ecosystem
digital literacy disaster recovery distributed adaptation distributed algorithms
distributed artificial intelligence distributed intelligence distributed processing dual reality
dxplanability eGovernment energy saving environmental impact event recognition
evidence-based reasoning evolutionary computation evolvability fuzzy logic systems
fuzzy technology genetic programming green ICT H2H/H2M/M2M high level programming
homeostasis human behaviors' dataset industrial design informational self-determination
intelligent agents intelligent assistant Intelligent Transportation Systems (ITS) interaction
interpersonal connections knowledge large-scale systems load local rules
machine learning manageability mass customization memory saving meta-user interfaces
methodologies micro-population mobile peer-to-peer networks multiagent systems
multiple scales neural networks NFC norms ontologies opportunistic networks
pattern analysis personal spheres pervasive ad hoc networks pervasive adaptation
pervasive computing pervasive intelligence pervasive roads pervasive sensing
pervasive services pervasive systems planning population protocols
power consumption privacy probability programming models quality of information
regulatory networks reliability resource allocation RFID robotics safety security
self-adaptation self-awareness self-optimization self-organization sensor networks
services shared spaces smart cities smart patina smart phone social intelligence

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The PerAda Research Agenda Book

Pervasive Adaptation

The Next Generation Pervasive Computing Research Agenda

A book by *Th. Sc. Community*

Emergence and Evolvability

At the architectural level, and from an abstract point of view, pervasive systems face the same problems as biological systems.

Human-centric Adaptation

Recent developments in smart spaces have tended to maintain a clear distinction between the system and user, and do not always immediately recognize that the system is completely contained within the user's environment.

Adaptive Pervasive Ensembles

Our models will never cover all possible situations that humans may engage. A community is the result of a complex system of interactions.

Quality of Life

Results from outward and inward research will be combined.

Pervasive Trust

Nowadays, the pervasive deployment of tiny devices with minimum storage and limited or no computational capabilities appears a realistic perspective. [...] A crucial issue in the effective deployment of such applications is to convince users to allow the delivery of the information that is collected; in fact, the exploitation of such devices in order to perform suitable operations should guarantee privacy of the user and trust that devices are not compromised.

(Alberto Marchetti-Spaccamela, 2010)

Societies of Artefacts

This vision goes beyond the idea of disappearing computers and complex systems of things and results in a new paradigm.

Dependable Pervasive Systems

The challenging fact about pervasive systems is that they are general purpose.

Socio-technical Systems

The importance of emerging collective intelligence cannot be denied, as it is the fact that pervasive computing systems are already present in our environment.

Autonomous Adaptation

many biological processes are already optimized for operating at high level of energy efficiency. Turning them into purposeful design patterns for "self-greening" pervasive computing systems represents one of the grand challenges ahead of us.

(Daniele Miorandi, 2010)

will take the form of a super-intelligent, global, collective and adaptive Social-ICT organism.

(Franco Zambonelli, 2010)

The PerAda Research Agenda Book

Selected Voices

Intelligibility

*“One particular usability aspect of interest is **intelligibility**, helping users to form an **accurate mental model** about **how to use an application**. This is important for allowing users to **understand** how the application works and to be able to **predict** what it will do in a future situation, and all of this will impact adoption and use.”*



Anind K. Dey

“Intelligibility in ubiquitous computing systems”

Pervasive Adaptation, The Next Generation Pervasive Computing Research Agenda
2011.

Social and Cultural Knowledge

*“Advanced data analysis tools will allow spotting trends, observing their **movement**, their **causes**, and **triggers**. This platform, will allow researchers to ... **explore social** and **cultural knowledge**. What do people **believe**? And how people **act**.”*



Adrian David Cheok

“Sociotechnical Systems”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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Lifelong Satisfaction

*“We believe that the next frontier in pervasive smart assistance will be to devise systems capable of **continuous - lifelong - co-adaptation** to the **user needs**. ...*

*However, **towards what should** be the system **adapted** to, and by **what should adaptation** be **driven**? We believe there is no better way than to be guided by the **satisfaction** of the user when he is interacting with the system.”*



Daniel Roggen

“Intelligibility in ubiquitous computing systems”

Pervasive Adaptation, The Next Generation Pervasive Computing Research Agenda 2011.

Virtual Coaches

*“Building on recent fMRI discoveries of **common spatial patterns among subjects when thinking of the same word**, there are numerous projects processing brain signals in an attempt to understand **what people are thinking**.”*



Daniel P. Siewiorek

“Quality of Life”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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2011.

Cognitive Adaptation

*“One of the next grand challenges for adaptive pervasive computing will be to may **devices that truly understand our mental and emotional situation** and try to **accommodate us.**”*



Jennifer Healey

“Human-Centric Adaptation”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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Uncertainty

*“Context-awareness is woefully limited in our computing devices and they **rarely do the "right thing"** or what we would prefer. We need to be able to **teach them how we want them to work for us...***

*What we need are the ability to tell if a user is **interruptable**, what information they **likely to need next**, what work/play they might be engaged in, and **who might be engaged in it with them ... our models will never cover all possible activities in which humans may engage.**”*



Gaetano Borriello

“Adaptive Pervasive Ensembles”

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Generation Pervasive Computing
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Collective Intelligence

*“The importance of **emerging collective intelligence** cannot be denied, as it is the fact that pervasive computing technologies will make collective intelligence so deeply embedded in our activities to make it impossible ... to distinguish about what aspects of our **"intelligence"** are to be **attributed to us as individuals**, to us as **member of the world society**, or to us as a **organs of a continuous and worldwide ICT-Social substrate.**”*



Franco Zambonelli

“Sociotechnical Systems
Pervasive Adaptation, The Next
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Harvest Ingenuity

*“.. a **new research approach** in pervasive computing centering on the investigation and development of human machines systems that increase the freedom, utilize the power of communities, **harvest** the **ingenuity** of a **large number** of **independent developers**, and develops **technologies** that **address people's basic needs...**”*



Albrecht Schmidt

“Sociotechnical Systems”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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Do-It-With-Others

*“... **innovation** is becoming an **active expression of citizenship** as much as it is a human pursuit to understand nature and create resilient and efficient tools. Hackerspaces, FabLabs, Makerspaces, DIYbio labs, Citizen science projects based on **Participatory Monitoring** and **Crowdsourcing** of Data represent these **alternative approach to R&D** ... Global and alternative innovation networks are developing around **Do-It-Yourself (DIY)** and **Do-It-With-Others (DIWO)** subcultures, ...”*



Denisa Kera

“Societies of Artifacts”

Pervasive Adaptation, The Next
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Socially Interactive Computing

*“We need to create a **techno-socio-economic knowledge accelerator** – a large scale multidisciplinary project that uses current and future ICT developments to address the **challenges of humanity** involving natural scientists and engineers.” (FuturICT)*



Dirk Helbing

“Adaptive Pervasive Ensembles”

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Steven Bishop

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Steven Bishop

“Adaptive Pervasive Ensembles”

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Life Patterns

“... technologies **allow** us - for the first time in history - to **collect large scale quantitative information** about another fundamental realm of nature: the **daily life** and **daily behavior** of people.

One of the most interesting applications of this research considers the **"quality of life"** and the **"life style"** ... to contribute the creation of **"stress-free societies"**.



Marco Mamei

"Human Centric Adaptation"

Pervasive Adaptation, The Next
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Knowledge Self-Organisation

*“... devising the most effective **mechanisms for knowledge self-organisation** - including **knowledge creation, propagation and dissipation** - to be used both at the individual (in the **workspace**) and the global (in the **information infrastructure**) levels ...”*



Andrea Omicini

“Human Centric Adaptation”

Pervasive Adaptation, The Next
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Digital Formations

*“... engineering of autonomous intelligent systems that co-exist with people in real and synthetic environments - also referred to as "**digital formations**" or "**digital spaces**" ...*

*engineered to **form societies, interact and compete** with other ecologies, collaborate with humans and develop their **own methods of conception and social norms**... ”*



Achilles Kameas

“Societies of Artifacts”

Pervasive Adaptation, The Next Generation Pervasive Computing Research Agenda
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Fluidity of Scale

*“... we further note that they [PerAda systems] can be thought of as **fractal** in **nature**, in that a system consists of many **subsystems**, each of which can be thought of as **system in itself** such that **each part is a reduced size copy of the whole** with respect to the general challenges of adapting to the environment and in that the **boundaries between the subsystems** are **fluid** ...”*



Ben Paechter

“Autonomous Adaptation”

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Software Ecosystems

*“A world of highly interlinked pervasive devices, smart objects and smart environments will only emerge if we succeed in **unleashing economic** and **commercial forces** that will create a self-sustaining Pervasive Software Ecosystem that provides a playing field for commercial (and non-commercial) software developers, providers, distributors, vendors and end-users.”*



Gerd Kortuem

“Intelligibility in ubiquitous computing systems”

Pervasive Adaptation, The Next Generation Pervasive Computing Research Agenda 2011.

Adaptation without Anticipation

*“We envision a system **design methodology** that **relieves** the developer from [”coding adaptation”] ... one should be able to **specify** the **desired global system behavior** using **appropriate high-level specification languages**.*

*The pervasive system should then be endowed with an infrastructure to **develop adaptation strategies** for its components such that the desired global behavior is delivered **across all possible situations**.”*



Friedemann Mattern

“Adaptive Pervasive Ensembles”

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Programming Ensembles

“... a big challenge is how to **program such populations in the large**. For example, one would like to state high level “**suggestions**” like “**reduce your energy spending**”, “**merge two populations**”, “**please elect a leader**”, “**spread the information by an epidemic process**”, “**increase the security level**” etc. and, ideally, the underlying population should be able to implement these in a scalable (independent of current population size) and flexible way (e.g. choose among a variety of routing methods).”



Paul Spirakis

“**Societies of Artefacts**”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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Digital Ecosystems

*“In what we refer to as '**digital ecology**' theory and practice, research aims to understand and advance the **interweaving** of **humans** and **ICTs** to create a world with social, physical, and cyber dimensions enabling a kind of social network in which humans are **not just 'consumers'** of data and computing applications ...*

*they are **producers**, '**players**,' and '**inputs**' whose interactions use the '**invisible hand**' of the market as they interact in complex, interdependent global-scale systems in areas such as energy production and use, and neighbourhood, district, city, and regional transport.”*



Mihaela Ulieru

“Quality of Life”

Pervasive Adaptation, The Next
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Dependability

“... these teams have to be **self-regulating**, in terms of a **dynamic re-allocation of roles, tasks, priorities** etc., which can be specified as part of the normative system itself. A major challenge is to **define dependability**, in terms of being able to **meet specific organizational objectives and levels of utility**, at the same time being able to withstand **component-loss, network outage or overload, and/or hostile behaviour.**”



Jeremy Pitt

“**Dependable Pervasive Systems**”

Pervasive Adaptation, The Next
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Dual Spatial Reality

*“Problem states can more **easily** be **transferred** from the **real** into the **digital domain** (by sensors) and the results of **reasoning processes** of the digital domain can directly be **transferred back into the real world** (by actuators). This tight connection between the digital and real world is what will lead to a **Dual Spatial Reality** ...”*



Antonio Krüger

“Adaptive Pervasive Ensembles”

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Mobile Augmented Reality

*“The challenge is **better connect remote people** than with a mobile phone employing **context aware augmented reality**. **Web 2.0 technologies** have added to people's ability to stay connect with colleagues, friends and family ... **PC's** ... do not scale down to smart phone form factors.*

***New technologies** need to be investigated to overcome these issues, but in addition take advance of the **mobile nature of people**...*“



Bruce Thomas

“Sociotechnical Systems”

Pervasive Adaptation, The Next
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4D

“What if the notion of images would change once and forever? What if instead of capturing, storing, processing and displaying only a single color per pixel, each pixel would consist of individual colors for each emitting direction?”

Images would no longer be two-dimensional matrices but four-dimensional ones (storing spatial information in two dimensions, and angular information in the other two dimensions). In electrical engineering, this four-dimensional structure is called photic field. In computer science, it is called light field.”



Oliver Bimber

“Intelligibility in ubiquitous computing systems”

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Flying!

*“Robotics platforms have approached these applications with increasingly **miniature flying** and **swarming platforms**. However, these platforms have significantly higher costs due to the array of sensors needed for navigation and communication ... needs to **leverage new mobility technology** while meeting stringent constraints associated with low-cost sensors.”*



Pei Zhang

“Autonomous Adaptation”

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Material

*“For pervasive systems, **computing is material** in two ways. First, pervasive systems must **intrinsically involve computing**. Second, and more subtly, the computing aspects of the system must be treated the same as any other **material** that affects the **feel and behavior of an object**.*

*... when computing is material, products will have "**smart patinas**", with their **wear patterns** determined both physically and computationally.”*



Tom Martin

“Sociotechnical Systems”

Pervasive Adaptation, The Next
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Applications

*“We have struggled to enable **large-scale explorations** of **socially meaningful applications**. These applications include **home health**, **elder care**, and **energy and resource monitoring**...”*



Shwetak Patel

“Intelligibility in ubiquitous computing systems”

Pervasive Adaptation, The Next Generation Pervasive Computing Research Agenda 2011.

Trustworthiness and Privacy

*“There is an obvious challenge in this personalization regarding the **privacy** of the collected information: **who** is to store all this data, **for how long**, **where**, and **what** is it used **for**?”*



Marc Langheinrich

“Supporting Digital Literacy in Pervasive Adaptation”

Pervasive Adaptation, The Next Generation Pervasive Computing Research Agenda
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Allow Collecting

*“A crucial issue in the effective deployment of such applications is to **convince users** to **allow** the **delivery** of the **information that is collected** ...*

*Collecting data while **guaranteeing user privacy** requires an interdisciplinary approach and new ideas from several areas.”*



Alberto Marchetti-Spaccamela

“Pervasive Trust”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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Respect!

*“**Respect** for peoples’ **ability to judge for themselves** and be assisted by machines where needed. Respect for peoples’ **desire for freedom of choice** and be supported by automation and decision support where appropriate. And respect for **fundamental human rights**, such as **privacy, security and safety**.”*

*A key research area is thus how to build respect for **humans’ social values** into the fabric of machines, to deepen our understanding of **value sensitive design**’.”*



Sarah Spiekermann

“Human Centric Adaptation”

Pervasive Adaptation, The Next
Generation Pervasive Computing
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Power-Awareness

*“... an important issue that will have **great impact** on how pervasive clouds will become is that of **energy consumption**. The development of **energy-conscious** and **power-aware resource allocation** protocols for cloud computing systems will open up more opportunities for the deployment of more pervasive technologies...”*



Albert Zomaya

“Societies of Artefacts”

Pervasive Adaptation, The Next
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it's Greening Time

*“The question now is: what if we design pervasive computing systems in such a way that they **self-optimize at run-time** their working parameters and internal configuration in order to **minimize their global carbon footprint** while **satisfying constraints related to the performance achievable** by applications running into it? How would such systems look like? What is the impact achievable in terms of **reduction of greenhouse gases emission?**”*



Daniele Miorandi

“Autonomous Adaptation”

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Electronic Waste

*“Pervasive computing at scale via portable devices has social implications in terms of **electronic waste**.*

*For example, there are **4.2 billion mobile phones** in use globally, with less than **3% typically recycled** according to a study ...Current mobile phones are replaced every 18-24 months, mainly to obtain devices with better performance...”*



Vinod Namboodiri

“Intelligibility in ubiquitous computing systems”

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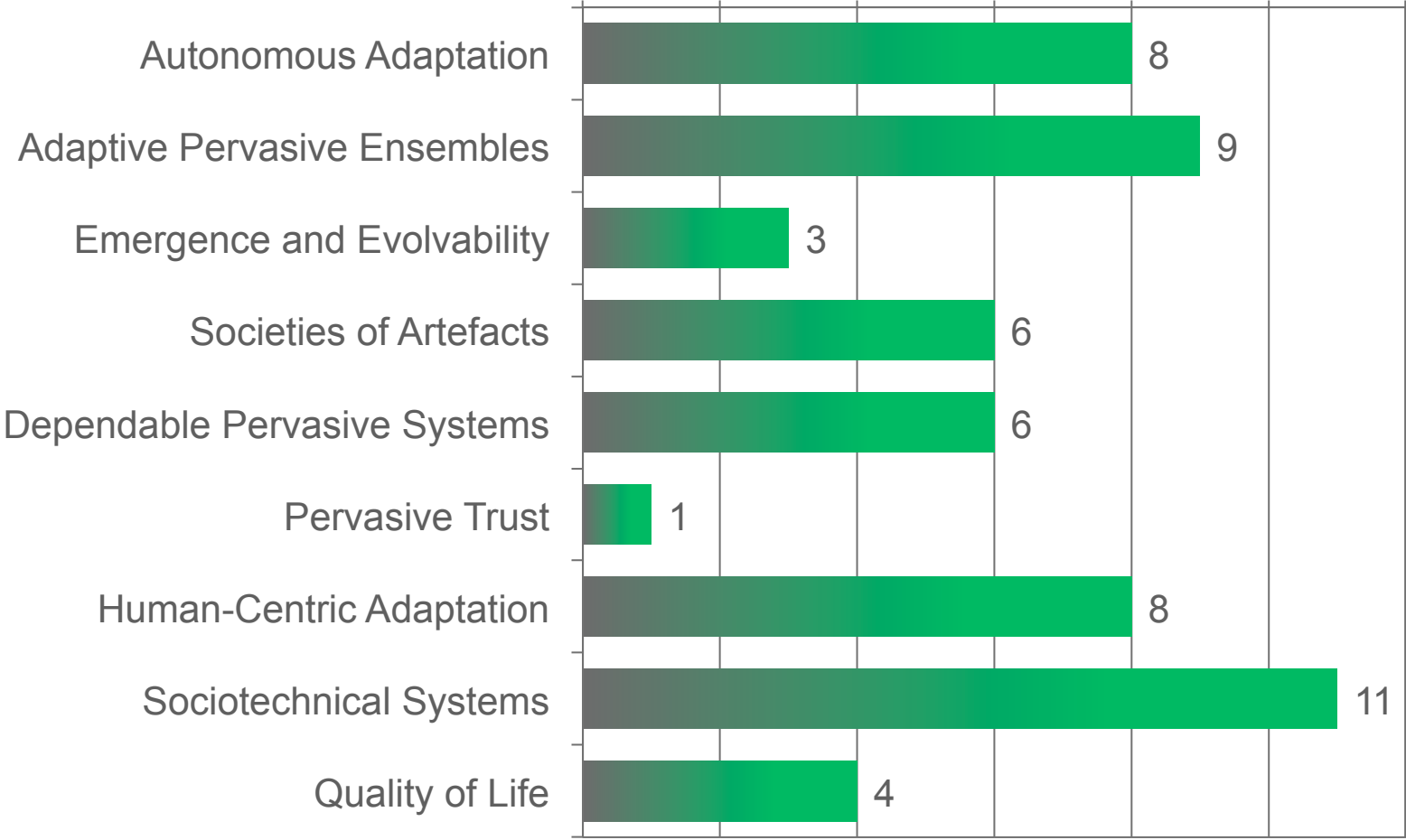
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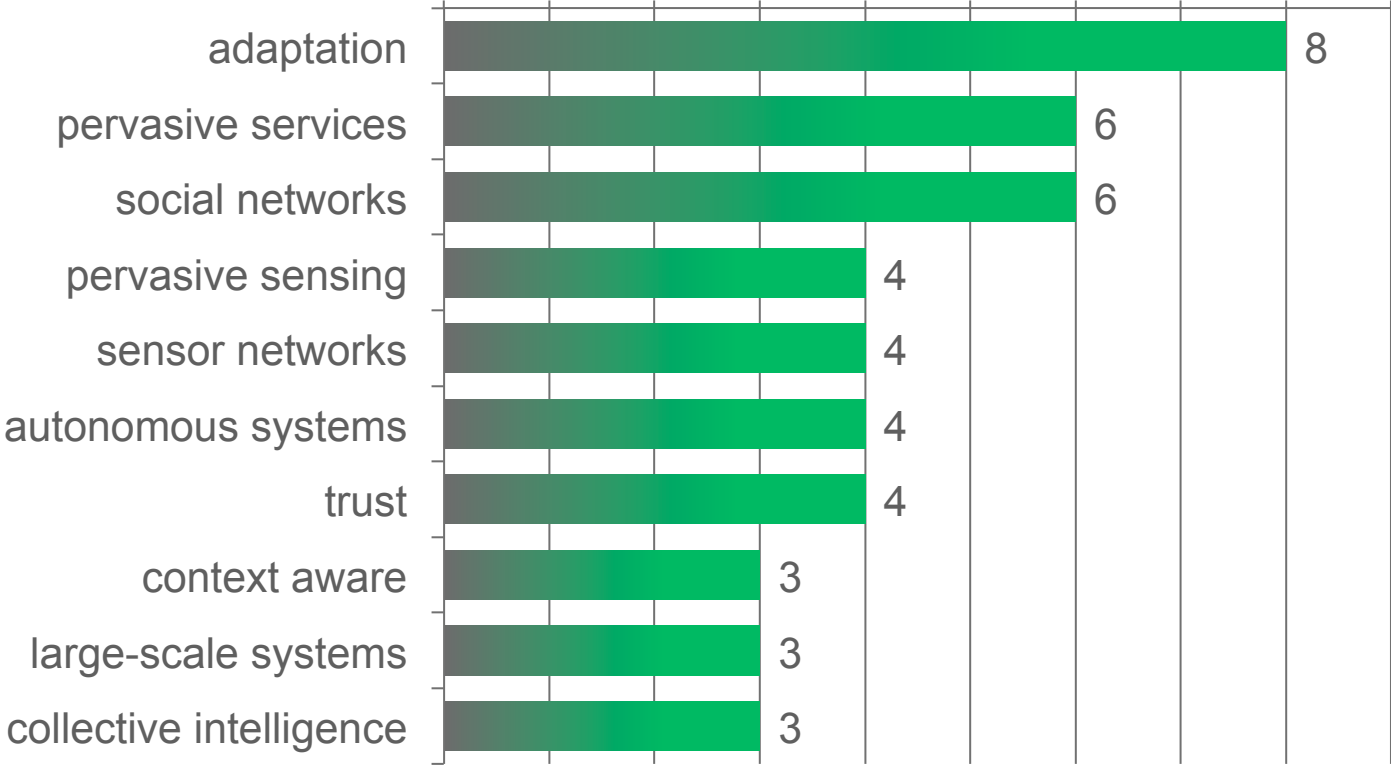
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Pervasive Socio-Technical Fabric

The Next Generation Pervasive Systems Research Agenda

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