
E-Health: Chances and Challenges of Distributed, Service oriented Architectures

C. Thuemmler^{1,*}, L. Fan², W. Buchanan², O. Lo²,
E. Ekonomou¹, and S. Khedim²

¹*Professor Christoph Thuemmler, PhD, Sofyane Khedim, Edinburgh Napier University, Centre for Applied E-Health, Sighthill Campus, Edinburgh, UK*

**c.thuemmler@napier.ac.uk*

²*Professor William Buchanan, PhD, Dr. Lu Fan, PhD, Owen Lo, Dr. Elias Ekonomou, PhD Edinburgh Napier University, Centre for Distributed Computing and Security, Merchiston Campus, Edinburgh, UK*

Abstract

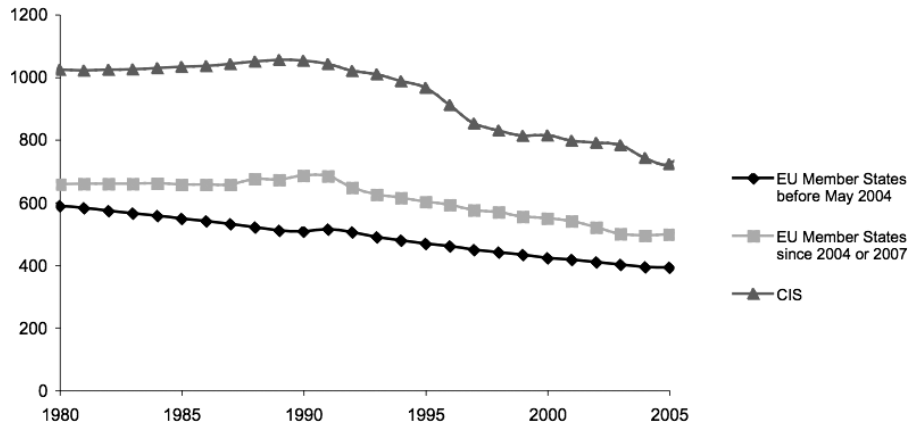
Societies are undergoing unprecedented demographic and socio-economical changes on a pace that has never been experienced before. Health care models are in transition to remain affordable for governments and individuals. Mobile technology and cloud computing will play a major role in order to help to achieve the necessary level of virtualization and service aggregation. There are, however, technological challenges in terms of security, trust, user friendliness and deployment of innovative E-Health strategies.

Keywords: E-Health, SOA, distributed system, DACAR PaaS.

1 Care Models in Transition

Societies globally are undergoing fundamental and unprecedented demographic changes. Although these changes might not yet be fully visible in some parts of the world, countries such as Japan, Germany and other European nations are already experiencing the impact of these developments on their social security, their well fare and their health care systems. Between 2000 and 2010 the old age dependency ratio in the EU (27 countries) has climbed from 23.2 to 25.9% and is expected to climb further to 31.37% in 2020 and 45.52 in 2040 [1, 2] (source Eurostat). The results sit well with an earlier study commissioned by the European Commission in 2003 looking at the development of people aged 65 and over and 85 and over comparing the population development of Germany, Spain, Italy and the United Kingdom. The authors came to the conclusion that “the number of people aged 85 and over in Spain is projected to be nearly three times higher in 2050 than in 2000”. In the UK the number of people aged 85 and over is projected to increase by a factor of two and a half. The projected increases in the numbers of people aged 85 and over in Germany and Italy are somewhere in between. As a percentage of GDP, however, projected long-term care expenditure are believed to rise faster in Germany (168%), followed by Spain (149%), Italy (138%) and the United Kingdom (112%) [3]. However, statistical data from the Eurozone suggests that healthcare expenditure could so far be kept relatively stable by the majority of the national governments over recent years [4]. The answer to these seemingly contradictory data lies in the strategic management of hospital-resources, which have been cut across the board. The number of hospital beds in the European Union (27 countries) dropped from 652.6 to 561.9 per 100.000 inhabitants between 1999 and 2008 with no evidence to suggest that this trend has been discontinued (Table 1) [5]. Consequently, the average length of stay (ALOS) has dropped significantly between 2003 and 2008 (Table 2) [6, 7]. All these data point towards an evolutionary systemic change with the point of care shifting successively from the center to the periphery of the system. Apparently more and more patients will be treated or cared for outside hospitals, in their homes, GP practices, nursing homes, day surgeries, day clinics, day rehabilitation, and — over the Internet. This can be understood as a move from the 19th and 20th century specialist centered, hospital based approach to a post modern, 21st century distributed patient centered care model which sits well with declared EU political targets such as patient empowerment and

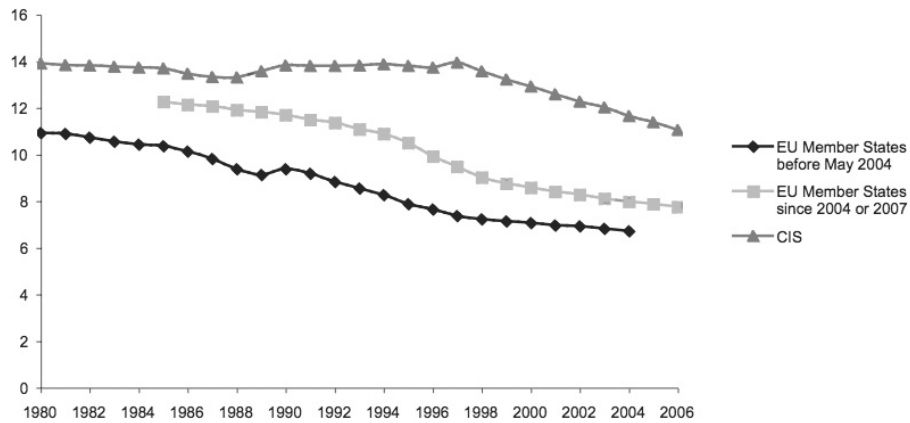
Table 1 Acute care hospital beds per 100 000 population in Europe.



Source: WHO Regional Office for Europe 2008.

Notes: EU: European Union; CIS: Commonwealth of Independent States.

Table 2 Development of length of stay (acute care hospitals only) in Europe.



Source: WHO Regional Office for Europe 2008.

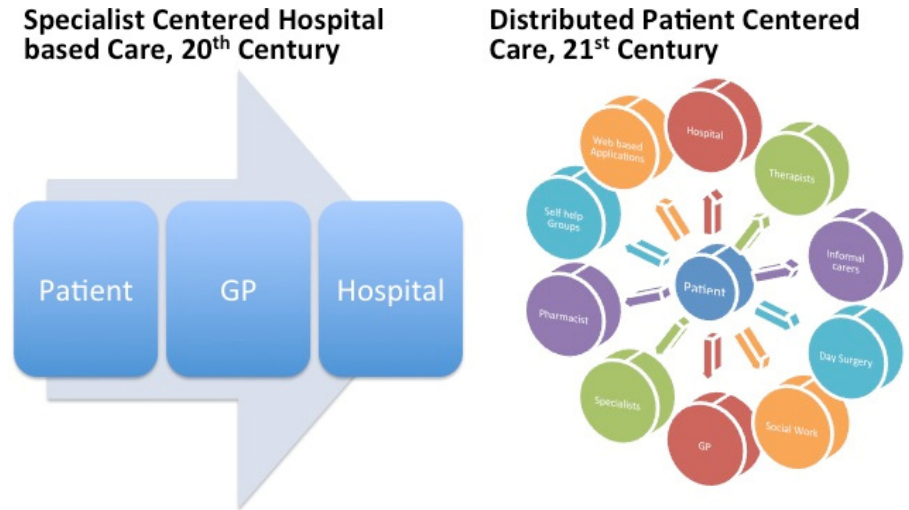
Notes: EU: European Union; CIS: Commonwealth of Independent States.

mobility [8]. Also there is a growing diversity with view towards the care providers. While health care budgets are not growing on the same rate they did in the 20th century the need and demand is rapidly growing due to demographic changes and the distribution of information via an ubiquitous world wide web. In order to cover the growing gap between accessible care and need and demands “informal carers”, carers without a specific training, frequently friends, neighbors and family members, have become relevant contributors to individual care. This is supported by US studies suggesting that there is a

strong positive correlation between available social (community) capital and access to health care [9, 10]. This development inevitably creates unwanted inequalities in society, which modern healthcare systems need to pick up on. Next generation Internet and the rapid spread of smart technologies including the Internet of things might be able to help to compensate in spaces where for a variety of reasons social capital is significantly lower than elsewhere. However, there can be no doubt that future care will be delivered by a growing variety of formal and informal carers, specialists, nurses, therapists, pharmacists grouped around the patient and “virtual care” will be provided over the Internet by self help groups, monitoring systems and other agents. There can be no doubt that the Distributed, Patient Centered Care model is the model of the future which will replace the static and economical unviable traditional care model of the 19th and 20th century (Table 3).

The flipside, however is that this approach clearly leads to further, growing fragmentation of individual care and subsequently to a significant increase in individual health care information as a more and more diverse community of formal and informal carers and health care organizations will be involved in the future care of people and care will take place across disciplines, domains,

Table 3 Global shift in care models.



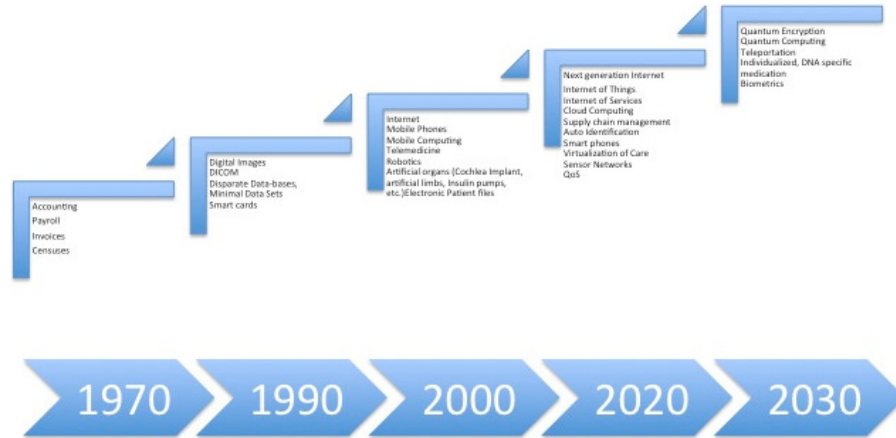
Distributed Patient Centered Care = Distributed Patient Centered Computing – The Evolution of E-Health Applications

locations and certainly across national borders outside well defined, controlled Institutions. Consequently, there is a growing need for international standardization to reduce uncertainty and offer increasingly mobile societies safety and confidence regarding the provision of their healthcare and patient confidentiality irrespective of their whereabouts. With view towards progressing globalization and increasing mobility of people there is the need to boost the confidence of people in a global system of networked care by establishing a shared set of values and standards in order to define the basis for human-machine and machine-machine trust where ultimately all the different elements of future virtualized care will be based on.

A clearly identifiable trend is the quickly growing medical data traffic resulting from the need to exchange medical data between different carers or care providing organizations across different domains and possibly different physical networks in a safe and secure manner. Information needs to be accessible at any time, anywhere, anyhow prior to any decision-making or action at the point of care. The Internet is playing an increasingly important role in the virtualization of care and will almost certainly reduce existing disparities and inequalities by providing better access to care to populations in remote areas, individuals with mobility impairments and low-income groups who struggle to afford frequent journeys to hospitals or other points of care. A recent Delphi study by the Oxford Internet Institute for the European Commission suggests that over the next 5–10 years the Internet will become vital for the vast majority of people in ordinary everyday living [11]. The Internet of Things (IoT) and the Internet of Services (IOS) will form a strong backbone for the provision of care at any time, anywhere, anyhow.

Information technologies and system solutions will be crucial for delivering care to a rapidly growing amount of people in the age of 65 and above but also have been identified as crucial factors for the management of chronic diseases by facilitating education, patient-empowerment and self-care [12]. In fact, there have been suggestions that “a shift in the balance between institutional and community care would be consistent with a policy of retaining as many older people as possible in their own homes and could help to ensure that institutional care is retained only for those with the highest levels of dependency, thereby helping to ensure effective use of resources” [3]. E-health including AAL is evolving (Table 4). In the early 70ies computing was used to manage administrative components of the delivery of care such as payroll,

Table 4 Evolution of E-health applications.



processing of patient data sets for invoices, etc. Ever since then there has been an evolutionary process from main-frame computers via PCs and server client models towards mobile distributed computing and lately Service oriented Architectures (SoA). The future has already begun with regards to the second generation Internet (Future Internet) and more blue-sky technologies such as quantum computing, quantum encryption and teleportation [13]. This might open the way for completely new treatment models through remote placement of pharmaceuticals through teleportation.

2 Cloud Mediated Interoperability, Virtualization and Service Aggregation

With the introduction of cloud computing we have taken an important step towards the virtualization of hardware, software and platform solutions and eventually the virtualization of care. Tele-health, Tele-medicine and the use of mobile devices will enable us to deliver care remotely, anywhere, anyhow, at any time and improve the quality of care in particular in rural areas in Europe, thereby reducing disparities among regions and populations. It is obvious that the future Internet consisting of the Internet of Things (IoT) and the Internet of Services (IoS) but also other physical networks such as 3G, 4G LTE and 4G will play a crucial role in moving the point of care closer to the patients and in particular those patients with multiple coexisting chronic conditions. In a

Delphi survey the Oxford Internet Institute found evidence that the evolution of the Internet will be more and more influenced by the end-users and. 75% of believed that in 10 years from now the Internet will become a basic factor in the daily life maintenance [14]. Current research projects in healthcare involving the application of service oriented architectures are focusing in the first place on service delivery und feasibility. The MUNICH platform (Multinational Initiative for Cloud Computing in Health Care) located at Klinikum Rechts der Isar, the main teaching hospital of technical University Munich, Germany is investigating the integration of data received from smart devices in operating theaters in order to improve patient safety and to improve documentation [15]. The DACAR project (Data Capture and Auto Identification Reference project) at Chelsea and Westminster Hospital in London, UK has been investigating the use of cloud technology to support Data Capture and Auto Identification technology following a critical report of the UK Department of Health on patient risks following insufficient use of readily available license plate technologies, such as Barcoding and RFID in the UK National Health Service (NHS) [16, 17]. The context is outlined in more detail in a review document of the UK Department of Health [18]. For the DACAR project, which we conducted on behalf of the UK Technology Strategy Board between 2009 and 2011, we developed an architectural model suitable for both, Linux and Windows server as shown in Figure 1. We also explored different scenarios for private, public and hybrid clouds taking into consideration the current controversial discussion regarding security and resilience in government clouds [19]. Healthcare is perceived by many as an ideal application scenario for cloud computing and the potential high level of service availability seems to make an ideal case for a public cloud scenario. This however needs to be balanced against privacy and safety requirements and the need for comprehensive governance which is deeply rooted in national and international legislation and standardization such as expressed through HIPAA and FDA regulations and the ISO standards — in particular ISO 80001 referring explicitly to the requirements for the protection of medical data networks and the ISO 27000 family which is referring to the application of information security management systems.

Considering the recommendations of the European Network and Information security Agency ENISA to governments to “take a staged approach in integrating cloud computing into their operations because of the complexity of cloud environments” we allowed for a maximum of scalability right

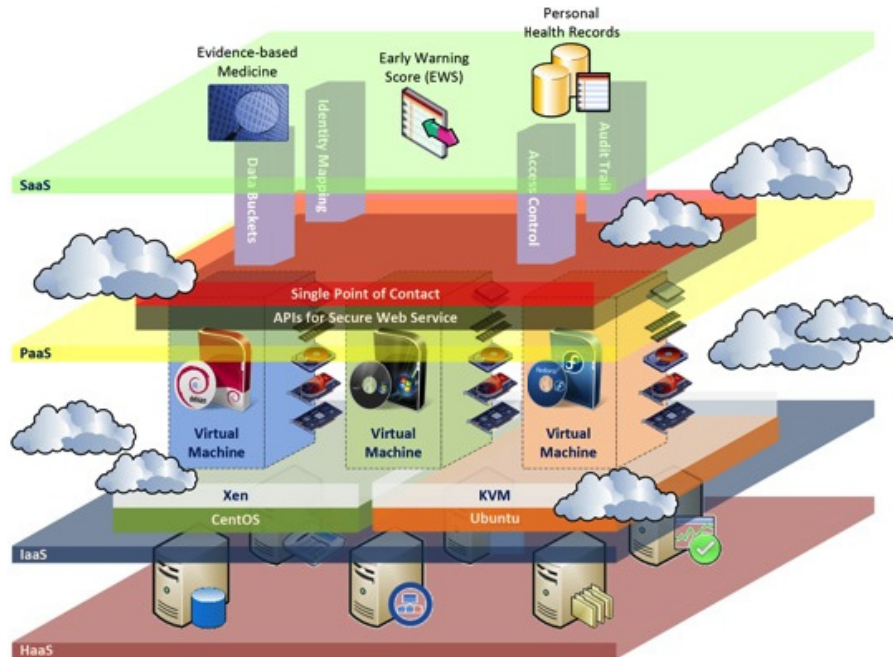


Figure 1 DACAR E-health cloud architecture.

from the start, so that the DACAR architecture can easily be run as a private cloud or as an element in a hybrid cloud [19]. The main contributions of the DACAR project are on the PaaS (platform as a service) level, specifically APIs to support the development of secure web services, a new and specifically for E-Health clouds developed information sharing policy syntax (SPoC — Single Point of Contact) and several E-health applications on the SaaS level. (SaaS-Software as a Service).

3 DACAR PaaS

The DACAR platform provides a stack of software components and services, which address the most common E-Health application requirements, so that a developer does not need to implement an E-Health application from scratch. Typical issues addressed by the DACAR platform include:

- Authentication — cryptographic protocols that allow an entity to prove to a remote end its identity.

- Authorisation — individual- and role-based policies that endow entities with access rights to resources.
- Data Persistence — long-term storage of medical attributes, including their core values and meta data.
- Data Integrity — functions that ensure data are accurate, complete and consistent during any operations.
- Data Confidentiality — mechanisms that assure stored or transmitted data are accessible only to those authorized to have access, yet well protected from possible disclosure.
- Audit Trail — mechanisms that keep track of a chronological sequence of audit records pertaining to internal and external events and their implications.

Figure 1 shows a three-layer architecture of the DACAR platform. At the bottom layer are Security and Confidentiality Mechanisms, which are used to meet the authentication, data integrity and confidentiality requirements. DACAR supports federated identity providers running a range of user authentication protocols, from traditional RADIUS and Kerberos, to recent OpenID and U-Prove [20, 21, 22]. In addition, DACAR provides libraries and APIs for application developers to implement secure SOAP services [23]. This allows a number of security functions, e.g. digital signature, integrity checksum, hashing and encryption to be applied to application-specific portion of communication payload. In the middle layer is the Single Point of Contact (SPoC), which is used to meet the authorisation requirement. A SPoC consists of two parts: a policy repository and a policy engine. The policy repository holds domain ontology, i.e. definitions of identities, roles, operations, services, objects, attributes and access rights. Each SPoC represents a single domain and multiple SPoCs form a peer-to-peer (P2P) network that represents a CoT. Information requests are routed through the P2P network to an appropriate SPoC, which uses its policy engine to check the requester's identity, role, and grants access rights according to existing rules in the policy repository. A SPoC authorisation is issued in the form of a Service Ticket or a Data Ticket, which are security tokens protected by the SPoC's digital signature. On the top layer are four system services:

- 1) The Data Bucket service offers long-term persistence of attributes and supports the Creation, Reading, Updating and Deletion

(CRUD) of attribute values and associated meta data. Each attribute is stored in a single data bucket hosted by a Cloud infrastructure, and its CRUD service endpoint is registered with the SPoC of the attribute owner domain. Any application service can put/get data to/from a data bucket, as long as it satisfies two conditions. Firstly, the service needs to know the qualified name of the target attribute, which is defined by domain ontology. Secondly, a rule needs to be established in the SPoC's policy repository to allow the service, or in the case of impersonation, the service invoker's identity or role, to perform CRUD operations over that attribute. If both conditions are met, the service is able to make a data request to the SPoC, which replies with a Data Ticket, carrying a reference to the CRUD service endpoint, a list of authorised operations, period of validity, and one-off session keys encrypted by the public keys of the requester and the CRUD service respectively. A Data Ticket may also carry data anonymisation and sanitisation instructions for the CRUD service to follow, as required by security policies.

- 2) The Identity Mapping service resolves user and object identifiers into pseudonyms, and vice versa. To enhance the contextual privacy of an eHealth application, opaque pseudonyms should be used in place of transparent user and object Ids, e.g. **12478c1abd** instead of **PatientNo:253**. Hence, the DACAR platform uses pseudonyms whenever it is possible, and only reveals real identities to authorized individuals, roles and services when it is absolutely needed.
- 3) The Access Control service enables patients to create, edit and remove information sharing policies about their own attributes. DACAR adopts a patient-centric point of view, and regards a patient as the real owner of his/her medical data. Hence, the rights of access to such data should be defined by the patients themselves to their trust circle. The access control service provides a friendly user interface, so that authenticated users can easily set up policies controlling what personal information is available to whom, and what medical services they would like to subscribe to.
- 4) The Audit Trail service gathers text-based logs from application services, showing who was the active user, and what operations the user has performed during a given period of time. eHealth

applications can benefit from the audit trail service in many different ways. Firstly, a sufficiently detailed audit trail enables the reconstruction of medical events and scenarios. Secondly, it keeps track of changes made to a system, and helps to roll them back when necessary. Thirdly, it provides evidence for digital forensics technologies, such as the Digital-DNA, to detect security anomalies and carry out countermeasures automatically [24]. Finally, it facilitates the monitoring and analysis of the usage of computing resources, and thus helps to improve on the scheduling and loadbalancing of the underlying cloud infrastructure.

4 Data Buckets

Another important component of DACAR's e-Health platform is the Data Bucket service. Data Buckets offer long-term persistence of atomic medical attributes and support the Creation, Reading, Updating and Deletion (CRUD) of attribute core values and associated meta data. A key to understanding DACAR's data bucket approach is its attribute oriented architecture. In other words, The DACAR platform groups medical data samples by attribute types, instead of individual patients. For example, one data bucket is dedicated to Blood Pressure, and another data bucket is dedicated to Heart Rate, and so on. For each data sample, both the core data, i.e. the value of the sample, and a rich set of meta data are stored. Meta data can include the unit of the value, the owner of the data, the person who captured the data, the device that was used, where and when the data was captured, etc.

5 Discussion

Demographic and socio-economic factors require extensive changes in how health care is delivered globally. In principle the technology to revolutionise health care is available across the relevant domains such as software, mobile phones, smart devices and the Internet. Future technologies will have the capability to make use of emerging technologies such as the Future Internet and the Internet of Things. The DACAR platform is an experimental example of an end to end service based on SOA and includes innovative technologies such as the Single Point of Contact (SPOCK) and the concept of data buckets, and

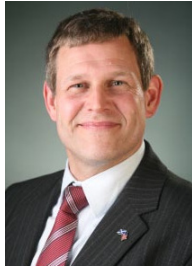
attribute oriented architecture where atomized data is being meta-tagged and can be selectively distributed for example to provide data safely and securely to researchers and epidemiologists without violating privacy and patient confidentiality. There are, however still deficiencies in the areas of security, virtualization and trust. With view towards trust machine to machine trust (M2M) and human machine trust needs to distinguished, as the technological approach is clearly fundamentally different. The first step in the approach towards human machine trust, which needs to be regarded as the “hard” factor is to eliminate distrust while the trust issue with regards to M2M trust it is clearly to establish strategies with a significant robustness and a reasonable reliability which is often referred to as “pervasive adaptation”. There are currently attempts under way to establish novel concepts of identification mainly build on the federation principle and using large, widespread application such as Google, VISA, mobile phone providers, etc. Although this principle is already in use on an industrial scale it is not clear if for example in future public sector clouds governments and government agencies will buy in to this concept or if separate identifiers will be required. Biometric approaches to support identification on the web and in particular in health care related applications have so far not met the initial expectations. Although revolutionary changes in health care will by far exceed people’s expectations the need for additional education for professionals and the wider public need to be carefully considered. Studies have clearly demonstrated a “digital divide” in populations and education has been identified as one of relevant factors [25, 26].

References

- [1] <http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdde510>
- [2] <http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdde511>
- [3] A. Coma-Herrera, Wittenberg Raphael (Editors) (2003) for DG EMPL/E1, European Commission, Long term Care Expenditure in an Ageing Society, http://ec.europa.eu/employment_social/social_situation/docs/european_study_long_term_care_en.pdf
- [4] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=hlth_sha_hp&lang=en
- [5] <http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tps00046>
- [6] http://www.euphix.org/object_document/o5579n27121.html

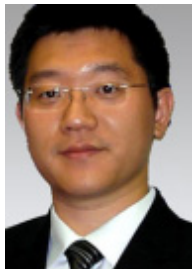
- [7] OECD (2010). Health at a Glance: Europe 2010, OECD Publishing p. 91.
- [8] Commission of the European Communities. Together for Health: A Strategic Approach for the EU 2008–2013 (White Paper), 2007.
- [9] M.S. Hendryx, M.M. Ahern, N.P. Lovrich, and A.H. McCurdy. Access to Health Care and Community Social Capital, 2002.
- [10] J. Lomas. Social capital and health: Implications for public health and epidemiology. *Soc. Sci. Med.*, 47(9):1181–1188, 1998.
- [11] C. Blackman, I. Brown, J. Cave, S. Forge, K. Guevara, L. Srivastava, M. Tsuchiya, and R. Popper. Towards a Future Internet, European Commission DG INFSO Project SMART 2008/0049, http://cordis.europa.eu/fp7/ict/fire/docs/tafi-final-report_en.pdf, 2010.
- [12] R. Busse, M. Blümel, D. Scheller-Kreinsen, and A. Zentner. Tackling chronic disease in Europe, World Health Organization 2010, on behalf of the European Observatory on Health Systems and Policies, ISBN 9789289041928, 2010.
- [13] R. Ursin, T. Jennewein, M. Aspelmayer, R. Kaltenbaek, M. Lindenthal, and A. Zeilinger. Quantum teleportation link across the Danube, *Nature*, 430:849, 2004.
- [14] C. Blackman, I. Brown, J. Cave, S. Forge, K. Guevara, L. Srivastava, M. Tsuchiya, and R. Popper, the Oxford Internet Institute. Towards a Future Internet, European Commission, http://cordis.europa.eu/fp7/ict/fire/docs/tafi-final-report_en.pdf, 2010.
- [15] www.munichplatform.eu
- [16] www.dacar.org.uk
- [17] Healthcare Quality Directorate, UK Department of Health. Coding for Success — Simple technology for safer patient care, Gateway reference 7768 http://www.dh.gov.uk/dr_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_066098.pdf, 2007.
- [18] Department of Health, UK. Review of Coding for Success Implementation, Gateway reference 14782, http://www.dh.gov.uk/dr_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/documents/digitalasset/dh_120722.pdf, 2010.
- [19] European Network and information Security Agency. Security and Resilience in Governmental Clouds, <http://www.enisa.europa.eu/act/rm/emerging-and-future-risk/deliverables/security-and-resilience-in-governmental-clouds/>, 2011.
- [20] C. Rigney, S. Willens, A. Rubens, and W. Simpson. Remote Authentication Dial in User Service, IETF standards RFC 2865, 2000.
- [21] B. Tung. *Kerberos: A Network Authentication System*. Addison-Wesley, 1999.
- [22] C. Paquin and G. Thompson. U-Prove CTP White Paper, Microsoft, Tech. Rep., 2010.
- [23] M. Gudgin, M. Hadley, N. Mendelsohn, J.J. Moreau, H.F. Nielsen, A. Karmarkar, and Y. Lafon. SOAP Version 1.2 Part 1: Messaging Framework (Second Edition), W3C Recommendation, 2007.
- [24] J. Graves, B. Buchanan, and N. Bose. Digital Fingerprinting Framework, US Patent: 61/116681, UK Patent: 0816556.5, 2009.
- [25] U. Sarkar, A.J. Karter, J.Y. Liu, N.E. Adler, R. Nguyen, A. López, and D. Schillinger. Societal disparities in internet patient portal use in diabetes: evidence that the digital divide extends beyond access. *JAMIA 2011*, 18:318-321, 2010.
- [26] M.D. Chinn and R.W. Fairlie. The determinants of the global digital divide: A cross-country analysis of computer and internet penetration. *Oxf. Econ. Pap.*, 59(1):16–44, 2007.

Biography



Christoph Thuemmler is Professor of E-Health at Edinburgh Napier University and Specialist for General Internal Medicine and Geriatric Medicine. He has studied Medicine, Political Science and Education at Heidelberg University and SUNY at Stony Brook and practiced Medicine in Germany and the UK before developing an interest in computing. Christoph developed an interest in patient flow models and flow monitoring techniques

before working on RFID and other smart devices in the healthcare wellness and ambient assisted living industry. In 2009 he was awarded a major grant for research on data capture and auto identification in acute care models and was accepted into the European Knowledge Cluster on the Internet of Things IERC. Over the last 3 years Christoph worked on cloud models to converge the IOT with other elements of the Future Internet. He has recently served as rapporteur for E-Health on the EU-China IOT expert group.



Dr. Lu Fan received the BSc (2003) degree in Computer Networking from Nanjing University of Science and Technology, Nanjing, China, and the MSc (2005) degree with distinction in IT Software Systems and the PhD (2009) degree in Computer Science from Heriot-Watt University, Edinburgh, UK. His research interests include Distributed Systems, Peer-to-Peer Computing, Grid Computing, Cloud Computing, Network Security,

Digital Forensics, Massively Multiplayer Online Games, and pervasive e-Health applications.

Currently he is a Research Fellow of Centre for Distributed Computing, Networking and Security, School of Computing, Edinburgh Napier University, Edinburgh, UK. Also, he is the Technical Lead of the Data Capture and AutoIdentification Reference (DACAR) project. He designed and implemented a Cloud-based e-Health platform, which reinforces the integrity, security, confidentiality and auditability of medical data throughout their life cycle, and facilitates the development, integration, and scalable and cost-effective delivery of e-Health services. The technology excellence of this e-Health

platform is a finalist in the BCS & Computing UK IT Industry Awards 2011, and the IET Innovation Awards 2011.



Bill Buchanan is a Professor in the School of Computing at Edinburgh Napier University, and a Fellow of the BCS and the IET. He currently leads the Centre for Distributed Computing, Networks, and Security, and works in the areas of security, next generation user interfaces, Web-based infrastructures, e-Crime, intrusion detection systems, digital forensics, e-Health, mobile computing, agent-based systems, and simulation. Bill has one of

the most extensive academic sites in the World, and is involved in many areas of novel research and teaching in computing. He has published over 27 academic books, and over 130 academic papers, along with several awards for excellence in knowledge transfer, and for teaching, such as winning at the I (please insert hear sign) my Tutor Awards (Student voted), Edinburgh Napier University, 2011, and has supervised many award winning student projects. He is also the finalist for an IET and a BCS Award for Excellence in 2011.

Presently he is working with a range of industrial/domain partners, including with the Scottish Police, health care professionals and the FSA. As part of the drive to create a World-leading infrastructure for security and cybercrime, he leads the Scottish Centre of Excellence for Security and Cybercrime which brings together a wide range of collaborators, including most of the universities in Scotland, the Scottish Police, the public sector, and a range of SMEs and large organisations. Current work includes initiatives on creating an e-Forensics Cloud across Scotland, and in organising a large-scale Symposium to engage a large number of stakeholders within Scotland, in order to focus on creating a World-leading infrastructure.

He has a long track record in commercialisation activities, including being a co-founder of Inquisitive System, which has progressed from PhD work to a university spin-out, though the Scottish Enterprise funded Proof-of-Concept scheme. This spin-out has also involved patenting novel security software in three territories around the World. His current work includes collaboration of TSB Grants with Microsoft plc on a £2 million project which aims to improve the care of the elderly using Trusted Cloud-based services, and with Chelsea and Westminster Hospital on a next generation Health Care platform.

This also matches up with other funded projects with the FSA and the Scottish Police.



Owen Lo is a PhD research student at Edinburgh Napier University. His current research involves looking at techniques for the simulation of patient data for evaluation of e-Health services along with further research into applying computational techniques for classifying patient risk models. Owen holds a BEng (First Class Hons) degree in Computer Networks and Distributed systems and was awarded the class award during the

2010 Graduation Ceremony at Edinburgh Napier University. Furthermore, he was awarded Lumison Prize at the Young Software Engineer of the Year 2010 Awards on his research in evaluating intrusion detection systems.



Elias Ekonomou graduated from the University of Salford with PhD in Computer Science focusing on Security in Wireless Sensor Networks (2010). He is also a graduate of the University of Abertay with BSc and MSc in Computing. Elias is currently working as a Research Associate at Edinburgh Napier University focusing in the security and privacy of future e-Health systems. His current project is to integrate e-Health systems

designed for either Hospitals or Home Care using cloud-based infrastructures (in collaboration with Microsoft and HoIP.) Elias has a strong interest in e-Health, Information Security and Computer Networks.



Abou Sofyane Khedim is a Software Engineer, Technical Lead at Kodit Database Ltd. He conducts a multitude of Healthcare projects such as the CareMagic Suite, a web-based healthcare application for hospitals. He worked as Visiting Researcher at Edinburgh Napier University within the DACAR project. He is also co-funder and CTO at Celestor Ltd, an R&D company aiming to provide a public eHealth cloud platform. He

has been running his own company, nTec Solution, an IT Contractor, providing consultancy for small SMEs.