Future Visions on Biomedicine and Bioinformatics 1

A Liber Amicorum in Memory of Swamy Laxminarayan
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A Tribute to Swamy

Lodewijk Bos

“Thank you so much for your note of invitation. I am very pleased to accept. I think this could be an exciting conference, it seems like a unique model. I look forward to working with you and Andy. I will certainly make it a point to get together with you, if I happen to be in Europe in the next couple of months.”

This was the first email I received from Swamy Laxminarayan, 23 November 2003. Andy Marsh had linked us together. A month later he accepted to be scientific chair of the ICMCC Conference in 2004, the conference that led to the ICMCC foundation of which both were co-founders.

Within 2 months after that first message, he had invited quite a number of friends to support the conference. Many of those are still involved in some way with the goals and works of ICMCC.

I was a complete stranger to the area of health technology. I have told the story many times; I wanted to organize a conference looking from the ICT angle towards the fields of medicine and care. As Swamy pointed out, a unique concept. In the only 22 months I had the privilege to know him and even call him a friend he listened to my ideas and supported and massaged them.

He opened doors for me, got ICMCC its membership of the IFMBE. I met him only five times in person; two ICMCC conferences, once at an IFMBE event in Italy, once for a meeting in London and once, in 2004, when I visited him in Idaho. Looking back, it seems unbelievable that someone, in a long-distance friendship (the time difference between Utrecht and Idaho caused him to say that ICMCC never sleeps), could have such an impact. Due to his support and belief in what I wanted to achieve with ICMCC we still exist as a foundation, despite the fact that in the meantime two more members of our board passed away and I suffered from a very aggressive cancer. During my studies in the arts as a young man I was taught
by the best in the world, but none of these great teachers had such an influence as this modest friend from Idaho.

He knew how to bring people together and for our second (and his last) ICMCC Event in 2005 he managed to bring together the president-elect of the IEEE (Prof. Michael Lightner), the president of the IFMBE (Prof. Dr. Joachim Nagel) and the president of the IEEE-SSIT (Prof. Brian O’Connell). And he definitely enjoyed it. Michael Lightner, Joachim Nagel, Jeremy Nettle, Winnie Tang, Lodewijk Bos, Swamy Laxminarayan, Brian O’Connell (ICMCC Event 2005)

This book is a tribute and an archive. Part 1 forms the tribute, where, 5 years after his death, some of his friends and colleagues give an impression of their work to date.

Part 2 is the archive, as we re-publish some of the last papers to which Swamy contributed, trying to show the present reader the width of his horizon. And finally an overview of what Swamy has done during his life, including an almost complete, more than impressive bibliography.

In grateful memory,

Lodewijk Bos
President ICMCC
A Comprehensive View of the Technologies Involved in Pervasive Care

Laura María Roa Romero, Luis Javier Reina Tosina, Miguel Ángel Estudillo Valderrama, Jorge Calvillo Arbizu and Isabel Román Martínez

Abstract It is widely accepted that the application of Information and Communications Technologies (ICT) in the healthcare environment leads to an improvement in medicine and healthcare delivery. The ageing of population, the prevalence of chronic condition, and other societal changes, as well as advancements in science and technology, require an evolution in healthcare delivery from centralized, general and reactive care, towards distributed, personalized and preventive care. The application of ICT can address these new scenarios but it is needed a methodological approach to establish common guidelines so that the developed systems are interoperable, reusable and future-proof. In this chapter, we present a methodology based on Open Distributed Processing (ODP) and standards to address the complexity of design and development of distributed systems in healthcare. This methodology specifies systems according to decomposition in viewpoints, each one focused on particular issues. We test this method by applying it to the general healthcare domain and particularizing it for a specific use case of an ICT application, a pervasive care system. We describe both the technology neutral viewpoints and those dependent on it.

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1 Introduction

Nowadays it is widely accepted that the application of Information and Communications Technologies (ICT) in the healthcare environment lead to the improvement of medicine and healthcare delivery. Thus, among the potential benefits, it can be remarked a more efficient management of health information; the possibility of remotely collecting data from wearable monitoring devices; more sophisticated and accurate techniques and methods for treatment and diagnosis; and so on.

In the near future, ICT will allow transferring to the clinical practice all the advancements in science and technology since the last decade (genomic and proteomic data, molecular images, miniaturization of monitoring devices, implanted sensor units, nanotechnologies…) in order to enhance the prevention, diagnosis, and treatment of diseases. In the meantime, a revolution in medical methods is being carried out towards a more personalized care. There are more and more resources centered on a single subject of care, for example, body sensor networks for real-time monitoring, studies or analysis made over different scales allowing a multilevel diagnostic, models and simulation tools for predicting drugs reactions or diseases evolution, etc. The application of ICT in healthcare will ease the current healthcare delivery evolve from using partial and isolated information to synthesizing all the knowledge available about each person in a cohesive whole.

Advancements and opportunities have led to the public awareness of the need for a new reorientation of health resources, creating a new conscience in the citizen toward healthcare delivery, who claims for the practice of a preventive medicine instead of the prevailing reactive medicine. Patients demand a pervasive care, more information and knowledge for a personalized healthcare, aimed to an improvement in the quality of life. Furthermore, citizens want to be more and more involved in their own healthcare and maintenance of well-being that will ease, for example, behavioral changes in their daily life (eating habits, physical activity routines…) to prevent or treat possible diseases.

Governments have not been unaware of the impact of ICT as a key factor to derive cost-effective solutions in this changing scenario, and have been forced to develop scientific policies to address the new challenges. Examples of these are the Ambient Assisted Living Joint Programme, launched by the European Commission, or the Spanish Law on the promotion of personal autonomy and care for dependent persons (Ley 39/2006, de 14 de diciembre, de Promoción de la Autonomía Personal y Atención a las personas en situación de dependencia; 2006 Dec 14).

This change of scenario is going to be sped up due to a set of additional growing concerns. During the last two decades different institutions and authorities have warned against a collapse of the public health system in the developed world, by the middle of the century, due to the confluence of diverse factors, including the population ageing, the prevalence of the chronic condition in extensive population groups, the change of social models and structure of family, the impact of
migration and population movements in the outbreak of infectious diseases, and
the corresponding growth in health expenditure. The application of ICT in
healthcare in a methodological way will be a cornerstone to address the new
scenarios and challenges, reducing the associated cost and enhancing the effi-
ciency of assistance processes.

A clear example of application of ICT is the paradigm of telemedicine defined
as the investigation, monitoring, and management of patients and the education of
patients and staff using systems that allow ready access to expert advice and
patient information, no matter where the patient or relevant information is located
[1]. The concept of telemedicine has gradually been widened from the use of
videoconferencing for remote consultation, toward collaborative medicine and
research through distributing system capabilities over high-speed networks and
information infrastructures.

The movement of health resources from a centralized scenario based on a
hospital towards a distributed one across organizations boundaries, including also
user home as a location where healthcare can be delivered, is acknowledged as a
key issue giving responses to the growing healthcare needs [2]. One of the pioneers
to envision this paradigm shift was the late Professor Swamy Laxminarayan [3],
who predicted in 2002 the shift of the information age towards a knowledge-
centric paradigm, through the opening of new frameworks for the integration of all
the biophysical, biochemical, and physiological knowledge for prediction pur-
poses. Hence, the telemedicine paradigm, which was first conceived as a feasible
solution, in the sense of cost-efficiency ratio, to deploy health services at under-
served areas, is progressively being shifted toward the concept of pervasive care
systems (PCS). The centralized health model is thus moved to a distributed one,
with the patient/citizen acquiring a more active role in the healthcare delivery
process.

Under the direction of the cited editorial article, several research groups and
projects [4–6] have made important advances in new settings for PCS. Although
under the basis of tele-healthcare is the claim that health services can be offered
more effectively and with less cost by providing connectivity with ICT [7] the
utilization rates for homecare projects are still falling well below expectations. On
the basis for such failure is the common practice to yield technological solutions to
particular cases.

This problem affects not only to PCS but also to all healthcare scenarios where
ICT have been applied. Due to design methodologies centered on particular
requirements and use cases, tackling the specific problem isolated from the whole
healthcare organization, consequent solutions lack of flexibility, scalability and
reusability. They can only be used in the particular context for which they were
designed as they have not taken into account other systems and the interoperability
with them. This situation results in a healthcare environment with a wide spectrum
of devices, systems and solutions; each one focused on one specific problem;
implementing heterogeneous, often proprietary, technologies; with few or no
possibilities of interoperability between them and reuse of their capabilities; and
finally, with large funds invested in solutions that in a few years may become obsolete.

The seek for new methodological approaches is thus justified. Proper methodologies are necessary to design general architectures that can be suited to every particular case in the healthcare environment. The vision of this environment as a cohesive whole will allow future solutions and systems to cooperate between them in order to reuse capabilities and achieve more complex goals, easing a more efficient and personalized healthcare delivery integrating all the knowledge related to one single person from diagnosis and treatments to daily life, genomics and monitored data. Thus, each particular solution and system will be a building block of a bigger system (the healthcare environment) that is evolvable and more and more complex, sophisticated and efficient.

In this book chapter, we face the application of ICT within the healthcare environment from a comprehensive vision of the whole complexity and potential solutions and technologies to apply. We present a methodological approach based on the Open Distributed Processing Reference Model (ODP-RM) (ISO 10746-1, 2, 3, 4: Information technology—open distributed processing—reference model, 1996) to develop open architectures of health, well-being and social care services. We address the requirements of interoperability, reusability and scalability by conforming international standards and recommendations in the whole development process. This methodology is technology neutral and widely enough to cover all the current and future requirements of scenarios and domains within the healthcare environment from healthcare delivery in hospitals to well-being outdoors services or remote monitoring in homecare.

As a proof-of-concept, we apply the proposed methodology to the development and deployment of a pervasive care platform. We present a general architecture for homecare, developed by our group, which stems from the concept of a personalized care through knowledge generation and we particularize on the underlying technologies. By following the ODP methodology, we start with the analysis of particular requirements of homecare delivery in relation to the subjects of care. As the methodology is technology neutral, it can be applied to current and future technologies and, in particular, we focus on the different solutions with today’s available technologies and short-term evolution, and paying special attention to the use of industry standards to benefit from interoperability between heterogeneous systems.

2 Materials and Methods

As it has been pointed out above, the healthcare environment is (and will continue) evolving from centralized scenarios to span across boundaries and domains becoming a complex distributed environment with several heterogeneous devices, systems and capabilities. Distributed systems can grant several benefits to healthcare delivery, but they present a set of issues to be addressed, mainly due to the complexity of their development and management.
The design, development, deployment, maintenance and evolution of a distributed system are highly complex tasks, involving an interdisciplinary, numerous and usually dynamic team. Consequently, the design could represent a substantial body of specifications needed to manage successfully the structure. The formalization of this structure is what we call system architecture. As a single engineering solution might not meet all requirements, this architecture must be flexible. Furthermore, since a single vendor may not have all of the answers, it is essential that the architecture, and any functions necessary to implement it, are defined through a set of standards, so that multiple vendors can collaborate in the provision of distributed systems. Such standards will enable to build open, integrated, flexible, modular, secure and easily manageable systems. Hence, taking into account all previous arguments, it is easy to understand that a coordinating framework for the standardization of the architecture is needed.

In a very simplified way we could say that such framework fundamentally consists of: a precise concepts language; a set of rules for the consistent structuring of system specifications; usually a set of fundamental or widely applicable functions for the construction of these systems; and several transparency prescriptions showing how to use these functions to hide users from the complexity of distribution. An efficient framework should allow different parts of the design to be developed separately if they are independent, but it should clearly identify those points where different aspects of the design constrain each other.

Different standards provide such framework for the formalization of distributed systems architectures. Two samples are the Reference Model of Open Distributed Processing (RM-ODP) and Model Driven Architecture (MDA) [8]. Although these standards differ in several aspects (like the use of viewpoints in ODP against a model approach in MDA), they have a similar philosophy; separating specifications targeting a technology-neutral viewpoint of the system, from those including details that specify how a particular underlying technology is used in the system. As a technology independent specification is suitable for a number of different platforms of similar type, this approach improves the interoperability between components designed by following the same specification although they were developed using different technologies.

One of the characteristics that makes more suitable RM-ODP over other standards is that it provides a coordinating framework for the standardization of open distributed processing that supports distribution, interoperation, platform and technology independence, and portability, together with an enterprise architecture framework for the specification of ODP systems. The framework for system specification provided by the RM-ODP has four fundamental elements: an object modeling approach for system specification; the specification of a system in terms of separate but interrelated viewpoint specifications; the definition of a system infrastructure providing distribution transparencies for system applications; and a framework for assessing system conformance.

By following principles as encapsulation and abstraction, RM-ODP allows the description of system functionality to be separated from details of system implementation, allowing the hiding of heterogeneity, the location of failure, the