UNDERSTANDING ICT STANDARDIZATION:
PRINCIPLES AND PRACTICE

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Association à but non lucratif enregistrée à la Sous-Préfecture de Grasse (06) N° W061004871

Published by: tredition GmbH, Halenreie 40-44, 22359 Hamburg, Germany.

ISBN: 978-3-7482-4742-5

PREFACE

With the support of the European Commission, ETSI has run a project to develop teaching materials to facilitate education on ICT (Information and Communication Technology) standardization, and to raise the knowledge level of ICT standardization-related topics among lecturers and students, in particular in the fields of engineering, business administration and law, in higher education. For this purpose, ETSI recruited a group of experts from different sectors, including standards organizations, academia and consulting companies. All of the experts have been actively involved in current standardization production and/or research, within the area of ICT.

To advance education about ICT standardization, the attractiveness of the topic among lecturers and students should be improved. Comprehensive and up-to-date teaching materials constitute a major way to convey the value and raise awareness of standardization. To provide high value for teachers and students, our main objective was to create a textbook and accompanying teaching/learning materials for standardization education that are tailored to the requirements and challenges of the ICT sector.

This project started by identifying best practices in education about standardization of ICT, the learning objectives and most appropriate teaching methods and tools. For this reason, the group of experts, who co-authored this textbook, carried out an intensive desktop research, and more than 25 interviews with leading international experts in standards education. The analysis of the information generated led to the design of the textbook structure and the accompanying learning material, including slides, visualizations, quizzes and case studies.

Readers of this book are not required to have any previous knowledge about standardization. They are introduced firstly to the key concepts of standards and standardization, different elements of the ecosystem and how they interact, as well as the procedures required for the production of standardization documents. Then, readers are taken to the next level by addressing aspects related to standardization such as innovation, strategy, business, and economics.

The contents of the book can be read in different ways. It can be read from cover to cover in a linear way, or readers may only focus on the specific chapters they are interested in. This is supported by the modular structure of the textbook, making the single chapters self-contained units that can be studied independently of other chapters. Each chapter begins with a list of learning objectives and key messages about what they will be learning in that particular chapter. For lecturers, this could be regarded as “meta-contents” to help decide which chapter of the book suits better the module or topic they are teaching.

The teaching resources comprise this textbook, which conveys the main theoretical knowledge. The text is enriched with examples from real standardization practice to illustrate the key theoretical concepts. Furthermore, the book includes case studies, where the ‘case’ can be a standardization document, an event or action, or a company that implemented a particular practice that is related to standardization. Each case study is intended to make readers reflect on a subset of the book’s learning objectives and messages, and it could be potentially used by lecturers as a building block for further learning activities more tailored to their particular teaching needs. Case studies also enable students to better see the application of the concepts learned and allow a classroom environment that promotes group discussion and interaction among students. Finally, each chapter includes a quiz to be used as a self-assessment learning activity.

Furthermore, each book chapter includes a glossary and list of abbreviations, which are useful in any learning context and indispensable in order to better understand and recall standardization knowledge. Finally, chapters have their corresponding summary and references.

Alongside the textbook, the project has produced a set of slides that are intended to serve as complementary teaching materials in face-to-face teaching sessions.

In addition to its use in undergraduate and Masters courses, the book consists of advanced topics that can serve as a starting point for graduates and PhD students interested in standardization research. The book also serves as guide or a checklist for experts already active in standardization activities by providing them with arguments for the justification and improvements of standards activities from a management point of view.

This book has been intended to reach all potentially interested readers, including those with disabilities. Hence, ETSI, the authors, and the publisher have committed themselves to ensure the accessibility of the book and its contents. For all interested parties there is also an electronic version of the textbook as well as the accompanying slides that can be downloaded for free from the ETSI website (www.etsi.org).

With the hope that all readers enjoy the learning process by using the textbook and the teaching materials, ETSI and the group of authors would welcome any comments and feedback that aims at improving the current materials. In addition, the authors would like to thank all contributors to this piece of work.

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FOREWORD

Step into any ETSI committee meeting, and you will encounter individuals with a wealth of professional experience, both in their technical areas, and in standardization processes. They acquired their technical knowledge through education, training and life-long learning. But where did they get their standardization skills? It is unlikely they received much formal education or training in standardization, beyond attending short courses run by standardization bodies, such as our ETSI Seminar.

However, standardization is not merely a technical subject. Standardization has become a key business process in the ICT industry. In our industry we talk of networked innovation and platform technologies. Software is modular and increasingly open source, while common components are found in many disparate products. Furthermore, companies make extensive use of patent protection for their innovations. In this environment, the path to commercial success for ICT products and services is often through standardization. Standardization enables common components, provides the platform technologies, unlocks a global market with all the attendant economies of scale. Standards essential patents may also release the value in protected innovations. This business-oriented view of the importance of standardization is not widely recognized, and hence it is often missing from our business and legal education.

To try to remedy this situation and prepare a new generation of standards professionals, ETSI, with the support of the European Commission and the EFTA Secretariat, has commissioned the development of teaching materials for a comprehensive education course on ICT standardization. This material could be used in a standards-focused module in engineering and scientific education. Parts of it could also be used in business and legal education. It could also be integrated into in-company training courses. The material, a textbook and a comprehensive set of slides, will be available from the ETSI website free of charge, and is designed to be adapted by lecturers and teachers according to their specific needs.

The teaching material has been developed by a team composed of researchers, lecturers and standards professionals. Indeed, some team members fulfil all three roles. This work expresses their independent professional opinion and does not form an official ETSI teaching on the subject of standardization. This teaching material is being trialled in universities and we expect its usage to grow. Please provide us with feedback as we plan to update it over the coming years. But mostly, I encourage you to use it, learn from it, teach others and share your knowledge of this important aspect of our ICT industry.

Luis Jorge Romero
Director General
ETSI

1 INTRODUCTION

Standards support our everyday life much more than we may think. Actually, we owe much of the progress in our modern life to standardization. Without standards, our life would not be as organized as it is today. We would have difficulties in doing basic things that we now take for granted. Imagine if the times or the track width of trains were not standardized, or imagine if we were not able to use our mobile devices once we are out of the reach of our operators' networks, for instance abroad.

Thousands of years ago, society recognized the importance of standardized measurements. Weight and distance, or length, cannot be measured without a common reference system agreed upon by people and institutions, in other words a system that is standardized. With technological progress, the need for standardization grows. The rapid progress in the area of information and communication technology (ICT) could not be achieved without the advances in standardization. Standardization and standards boost progress and create a basis, upon which technology can evolve.

Though important, ICT standardization and its methods remain a topic that is not easily accessible. It seems that this field is becoming increasingly limited to the expert and remains mysterious to the non-expert. So far, there is research published in the area, but there is no textbook that makes the topic easy to digest by the interested student. We believe that standardization, in particular in the area of ICT, deserves more attention. The principles of ICT standardization should be taught in class in order to convey essential knowledge to students about such an important field.

This textbook is an attempt to make ICT standardization accessible and understandable to students. It covers the essentials that are required to get a good overview of the field. The book is organized in chapters that are self-contained, although it would be advantageous to read the book from cover to cover.

The second chapter provides a high-level overview of the scope and process of standardization, while introducing the main subjects that are covered in detail in subsequent chapters. It is a synthesis of the basic concepts mainly expressed in a simple and example-based way.

In Chapter 3, readers are introduced to the key concepts that will guide them through the tricky landscape of standardization. In particular, they will learn about Standards Development Organizations (SDOs), and the mechanisms that support their cooperation and coordination.

Chapter 4 addresses several topics related to the development of high-quality formal standards. The process of producing standards is described in detail and illustrated with several examples. As standards are written by standardization experts, the chapter describes their roles in the standardization process as well as the technical and personal skills that enable them to carry out their daily tasks. Chapter 4 also describes the main activities and responsibilities of the standardization experts and how they interact with their peers, inside the standardization group and within their own organizations.

To be successful in a competitive marketplace, companies need to be innovative. They have to constantly look for new opportunities for innovation. Chapter 5 deals with the interdependencies between innovation and standardization. Whereas innovation is understood as the result of a creative process, standards rather represent stability and identification of common grounds. Those aspects are—at least at a first glance—not necessarily conducive to innovation. Standards are the result of many years of knowledge gathering and structuring. As such, standards represent an important source of codified knowledge. Although they are crucial to the company's success, many companies do not see the relationships between standards/standardization and innovation. Chapter 5 will, in particular, focus on the so-called innovation potentials in standardization, in other words the aspects that make standardization conducive to innovation.

Chapter 6 looks at participation in standardization from the perspective of an organization interested in getting involved, looking both at strategic and technical aspects. The chapter also deals with the operation of standardization efforts and organizations, including voting, and the impact of external influences. The chapter concludes with information regarding how to select standards and specifications for a given application.

Decisions related to Intellectual Property Rights (IPR) have a significant impact on a company's business success. Given a new technology, companies can choose from a menu of possible options: either go for patenting, do standardization, implement a mixed strategy or keep their technologies secret. To be successful in the market, companies have to make the right decisions in order to capture the value of their innovations: to patent, to standardize, or to pursue a mixed strategy? Chapter 7 tackles this issue by introducing a decision tree that helps an informed decision be made, once a new product or technology is created.

Chapter 8 provides an in-depth analysis of the economic contribution of standards. Standards are an important instrument in the diffusion of new technologies and technological know-how and contribute significantly to economic growth. Although our world is strongly reliant on standards, their real effects on the economy are less obvious. Like patents, standards are carriers of codified knowledge and can provide companies with state-of-the-art knowledge. This chapter also analyses the role of standards in public procurement. Governments use standards in the context of public procurement to improve transparency and guarantee a high quality of public services. Companies who are willing to apply for public tenders need to comply with the indicated standards. Thus, the government can indirectly encourage the adoption of standards by companies, and therefore support the innovative strength and technological progress of a nation.

2 INTRODUCTION TO STANDARDS

This chapter aims to provide a high-level overview of the scope and process of standardization, while at the same time introducing the main subjects that will be covered in greater depth and detail in the following chapters.

It is an initial introduction to the basic concepts of the book by using examples. The chapter can also be used standalone for providing the fundamental knowledge on standardization to a general audience.

This chapter has the following objectives:

a) to identify what standards are, what they are not, and how they impact everyday life;
b) to explain what benefits standards bring and what undesired drawbacks they may imply;
c) to introduce the complex international standardization landscape, where multiple organizations operate and collaborate to create standards;
d) to briefly explain the structure of the standards development process;
e) to provide hints about the use of standards; i.e., how to select relevant standards and how to go through standards documents.

LEARNING OBJECTIVES

- Students should grasp how standards—generally defined as "widely agreed ways of doing things"—are needed to guarantee the interoperability of "things", which is essential to the functioning of our technological world;
- Students should understand the role of Standards Development Organizations and how their structured approach to standards development benefits innovation, trade and society; they should also realize that ill-conceived usage of standards and the standards development process has its drawbacks;
- Students should get a glimpse of major SDOs active in the ICT sector;
- Students should understand the main basic concepts of the SDOs' processes and the characteristics of the main deliverables.

2.1 BASICS OF STANDARDIZATION

2.1.1 INTRODUCTION

The online Cambridge dictionary provides the following definitions for the term "standard": "a pattern or model that is generally accepted" (example, "This program is an industry standard for computers") and "a level of quality" (example, "This piece of work is below standard/is not up to standard."). As we will see in the next part of this chapter, both definitions may apply to the specific purpose of our work.

DEFINITION

For the time being, we will primarily stick to the first definition, which, in an even more general and informal way, can be expressed as such: a "standard" is "a widely agreed way of doing something". Depending on the specific area of application, "doing something" may be replaced by, for example, "designing a product", "building a process", "implementing a procedure", or "delivering a service".

Clearly, "standard", i.e., "largely agreed and common" ways of doing things provide many benefits; our technological world simply would not work, or, at least, it would be harder and more uncomfortable to make it work without "standards". In fact, let us think about how we, computer users, would be in difficulty if each computer maker used a different way of arranging keys on a keyboard, or if each producer of computer peripherals used its own specific connectors or, even, its own protocol[1] (Figure 2.1). On the one hand, we, as users, would be confined to choosing from a restricted selection of compatible devices and, on the other hand, computer and peripheral makers would be forced to pre-select, by design, the counterparts they want to interoperate with.

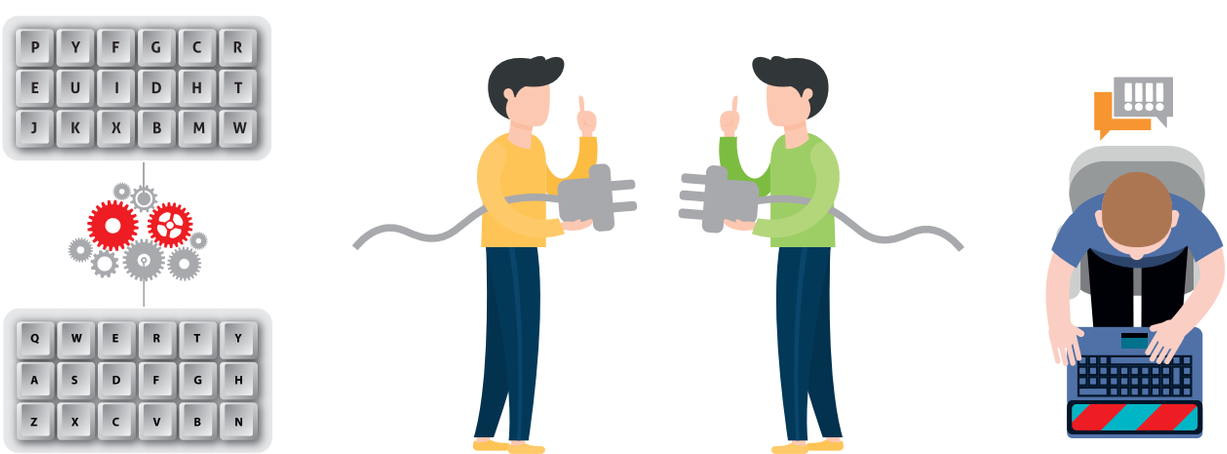

***Figure 2.1**: Technologies would not work without standards.*

1 *Here, "protocol" means the set of messages that two devices (in this case, a PC and a connected peripheral) need to exchange to interoperate. The protocol defines the messages to be exchanged to perform a certain action (for instance, to send a document from a PC to a printer), their logical content and format, as well as their sequence.*

Looking at the examples above, which, as described in Section 2.1.2, could be extended to a wide variety of other fields, it is evident how a common and agreed "way of doing things" is largely beneficial to all players in a business sector.

Such convergence towards common and agreed-upon solutions can happen with two different processes, which can be a first criterion to classify "standards". Indeed, we may distinguish between two main different types of standards, according to the way they are born: "de facto standards" and "formal standards".

A "de facto standard", also known as "standard in actuality", arises when a winning solution is widely and independently adopted by different industries within a market segment and products developed on such a basis are widely accepted by customers.

EXAMPLE

Some examples of "de facto standards" are:

- The most widely used keyboard layout (QWERTY) dates back to 1864, when it was patented by Christopher Sholes. The later Dvorak version (1936, by August Dvorak) was intended to increase typing speed, but owing to the already consolidated position of QWERTY, was not as successful (though natively supported by most modern operating systems).
- HD DVD (High Definition Digital Versatile Disc) and Blu-ray Disc are two digital optical formats for new-generation DVDs suitable for high-definition content.

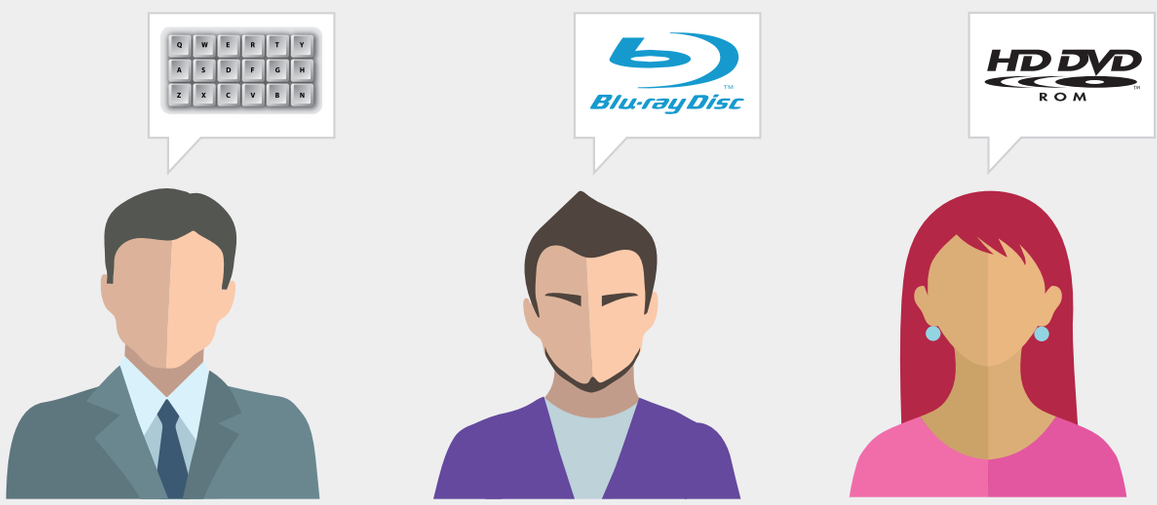

***Figure 2.2**: De facto standard*

Differing from "de facto standards", "formal standards" are produced by Standards Development Organizations (SDOs).

SDOs are organizations whose statutory purpose is to develop standards and that put in place formal well-defined procedures to guarantee a fair development process.

Figure 2.3 shows just a few examples of SDOs, which include, for instance, ISO (International Organization for Standardization), IEC (International Electrotechnical Commission), ETSI (European Telecommunications Standards Institute), and ITU (International Telecommunication Union). More examples of SDOs and a description of their objectives and operations are provided in Section 2.1.3 and later sections.

***Figure 2.3**: Examples of SDOs*

De facto standards can become formal standards, if and when they are published by a SDO. Examples of these standards are HTML (HyperText Markup Language), developed in the early '90s by Tim Berners-Lee at CERN in Geneva, Switzerland, and constantly maintained by the World Wide Web Consortium (W3C), and PDF (Portable Document Format), created by Adobe Systems in 1993 and later formally standardized by ISO (ISO 32000, ISO 19005-1:2005).

2.1.2 STANDARDS IN EVERYDAY LIFE

Formal and de facto standards affect our everyday life, as many technologies, products and services are based on established standards. Later in this section, we provide a few remarkable examples that highlight the strong link between our everyday life and standards. We also quote some of the most prominent SDOs. Note, however, that more detailed information about these organizations' scope and history can be found in Section 2.3 and in Chapter 3.

EXAMPLE

Example 1 – Smartphone browsing.

One of the actions that we do most frequently today is surf the Internet, especially by making use of mobile devices such as smartphones. Figure 2.4 highlights some of the technological components that enable a smartphone user to browse the Web in the same way as through a wired desktop computer. If we look at the number of different devices (such as smartphones, mobile and wireless network equipment, and servers) and software modules (communication protocols, browsers, and web server applications) involved that have to interoperate to support this familiar scenario, despite being produced by different vendors, the importance of a shared and interoperable technical approach is clear. In fact, as shown in Figure 2.4, there are many formal standards that provide the basic reference design rules for the implementation of the main components that populate this scenario. Some of these standards are related to the user equipment regarding its hardware characteristics, also taking into account safety issues. Other standards cover connectivity among user devices and mobile and wireless networks as well as the overall functionality of the same networks. Lastly, a number of other standards are related to the functionality of the Internet and the protocols to support web browsing.

Smartphone producers can refer to ETSI and CEN-CENELEC standards for radio and telecommunication terminal equipment, which set essential requirements for safety and health, electromagnetic compatibility and the efficient use of the radio spectrum.

As far as mobile network interfaces and functionality are concerned, smartphone makers and mobile network equipment makers and operators will likely refer to the 3rd Generation Partnership Project (3GPP), which constitutes the leading organization for the development of globally accepted solutions. 3GPP is the SDO that defined the widely popular "third generation" UMTS and "fourth generation" LTE protocols to support data exchange over a mobile network. Similarly, to support data connectivity through wireless area networks, smartphone makers and equipment makers can refer to the widely used Wi-Fi and Bluetooth technologies, which are standardized by the IEEE and the Bluetooth Special Interest Group (SIG), respectively.

Compatibility and interworking issues are particularly challenging in the Internet environment, where a complex infrastructure needs to support information exchange among a wide range of heterogeneous devices and software applications. For this reason, despite the continuously evolving nature of Internet technologies, there is a need to establish common rules that ensure interoperability[2].

The main contributor to the definition of standard solutions for the operation of the Internet is the IETF, whose self-imposed mission (IETF, 2018) is "to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use, and manage the Internet".

IETF standards cover the basic functionality of the Internet, including, among others, node addressing[3] and naming[4], data traffic routing[5], traffic management[6], and network security. Major IETF contributions include Internet Protocol "version 4" and "version 6" (IPv4 and IPv6), OSPF (Open Shortest Path First) and BGP (Border Gateway Protocol) routing protocols, and the IPsec (IP Security Architecture). As a complement to IETF standards, the World Wide Web Consortium (W3C), defines protocols for web functionality; W3C develops standards for languages widely used to build web pages, such as HTML (HyperText Markup Language) and XML (eXtensible Markup Language), which foster the interoperability of different platforms on the Internet.

Lastly, always with the aim of ensuring interoperability, standard activities also apply to tools for developing web content and applications. One notable example is ECMA and ISO collaboration to develop a standard scripting language that is the base for the popular JavaScript technology, used to build interactive web pages and provide online software applications.

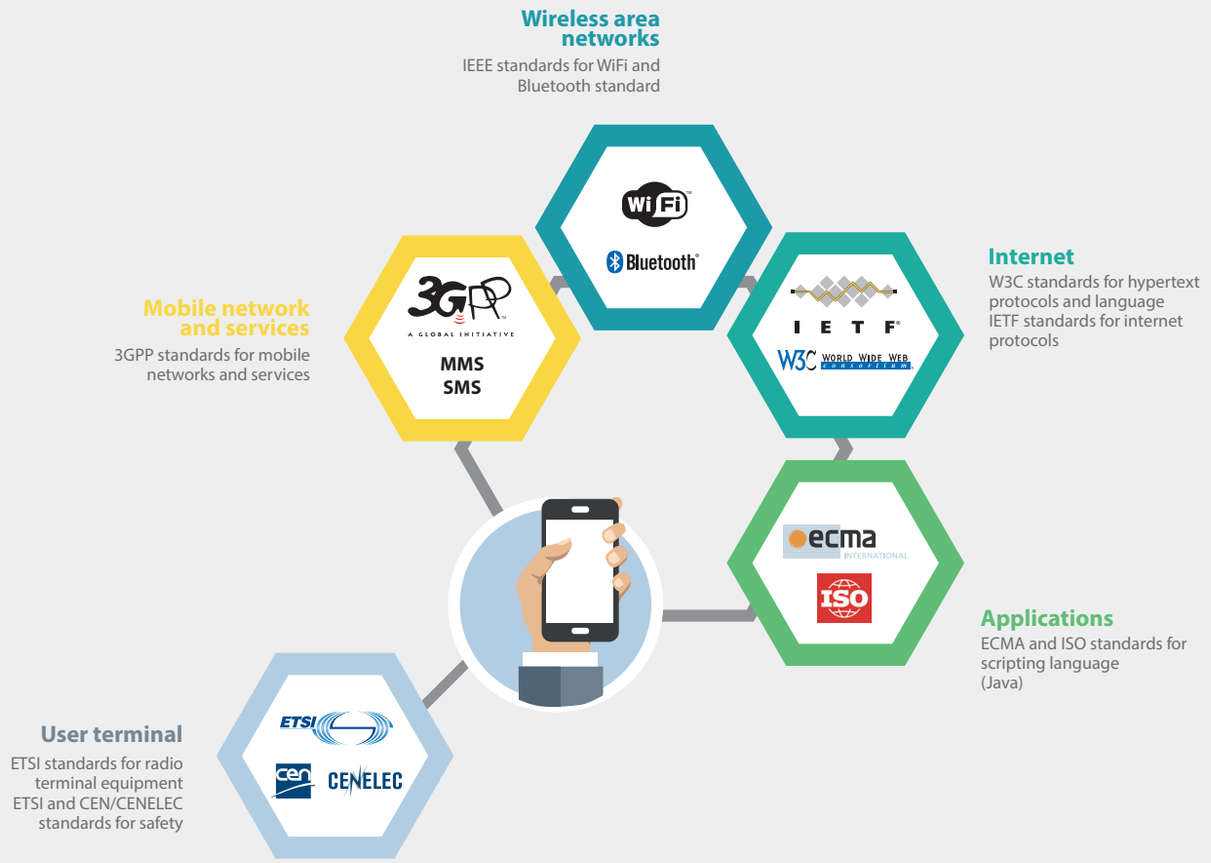

***Figure 2.4**: Standardization enabling smartphone web browsing.*

2 *For our purposes, we can define "interoperability" as the ability of different devices or software applications to exchange data and use the information that has been exchanged. This implies that interoperable devices or software applications share common protocols (as defined in Section 2.1.1).*

3 *To give an example, we can say that each Internet device (such as a desktop or laptop computer, server, scanner, printer, modem, router, smartphone, tablet or smart TV) is assigned an address (called an IP address) that uniquely identifies the device within its network. Every message transmitted over an internet network contains a "source IP address" (i.e. the IP address of the device that generated the message) and a "destination IP address" (i.e. the address of the destination device) and the network infrastructure is responsible for getting the message from its source to its destination.*

4 *An Internet device can be assigned a device Internet name (such as www.etsi.org), which uniquely identifies the device within its network. The Internet infrastructure includes specific mechanisms for the name resolution service, i.e., to remap the device name into the relevant IP address. This mechanism lets us surf the Internet by using an easy-to-remember string instead of an alphanumeric IP address to identify our target device.*

5 *By routing we mean the set of mechanisms used within the Internet infrastructure to determine what path a message has to follow through the network to get to its final destination, identified by the "destination IP address".*

6 *Traffic management aims to optimize the performance of the Internet network. It may include provisions to classify and prioritize traffic, so as to guarantee that the portion of traffic that belongs to a certain class complies with determined performances (for instance, having a fixed maximum network transit delay).*

Example 2 – Using a Personal Computer.

Unlike the example described above, a stand-alone PC appears to be a relatively "simple" and self-contained object that each manufacturer could build using its own proprietary technology. Yet, in this case as well, a design approach based on common standards has many benefits. It allows basic components from different providers to be used interchangeably, to simplify connectivity with external peripherals and networks, and to guarantee its users a safe and environmentally compatible product. As a matter of fact, a 2010 paper (Biddle & al., 2010) identifies 251 technical interoperability standards implemented in a laptop computer, and estimates an actual total number (including aspects of quality, safety, performance, measurement, environment, accessibility, design process, manufacturing process and electromagnetic compatibility) that might well be over 500. Out of the 251 identified standards, "202 (80%) were developed by SDOs and 49 (20%) by individual companies" (Biddle & al., 2010). Figure 2.5 shows only a few of the standards that may be involved. They include JEDEC for building hardware components; INCITS and VESA's standards for memory, storage and display components; and PCI to interconnect heterogeneous cards; mechanical, physical, and software interfaces to plug and connect peripherals and networks, such as IEEE's Wi-Fi and Ethernet; the IETF's protocol stack; HDMI for audio/video peripherals and USB for a wide range of devices; and basic software tools such as compilers for ISO C/C++ programming languages. This gives an idea of the complexity of the standardization environment in a product that has become part of everyday life. Most likely, however, with the advancement oftechnology in recent years, the figures presented may have significantly increased.

***Figure 2.5**: PC-related standards.*