The Intelligent Web

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This article presents the Web evolution towards the Intelligent Web. The new Web requires designing of applications with learning algorithms and mechanisms for the self-organization of a hypertext network. These algorithms will allow the Web to autonomously change its structure and organize the knowledge it contains, by learning the ideas and preferences of its users. Intelligent applications would find their way onto the Web as Web Services through Enterprise Information Portals and through the evolution of Semantic Web Architecture. The Semantic Web will allow both people and programs to have quick and accurate access to Web information and services. Capturing and exploiting the meaning of terms it will transform the Web from a platform that focuses on presenting the information, to a platform that focuses on understanding and reasoning with information.

Keywords: *Semantic Web, Web Services, intelligent agents*

1 Introduction

The concept of an Intelligent Web weaves together important concepts related to the growing and evolving system of information technology software and hardware (the Internet). Intelligence (in particular, the ability to learn) and "wireless" (with its attendant mobility and convenience) will deliver increasingly capable information services to mobile users any time and anywhere. The Intelligent Web is a network that provides any time, anywhere access to information resources with efficient user interfaces and applications that learn and thereby provide increasingly useful services whenever and wherever we need them.

The future wireless communication process will start with a user interface based on speech recognition by which we merely talk to a personal mobile device that recognizes our identity, words, and commands. The personal mobile device would connect seamlessly to embedded and fixed devices in the immediate environment. The message would be relayed to a server residing on a network with the necessary processing power and software to analyze the contents of the message. The server would link to additional Web resources that could then draw necessary supplemental knowledge from around the world through the Internet. Finally, the synthesized message would be delivered to the appropriate parties in their own language on their own personal mobile device.

The development and deployment of scalable, production level, Intelligent Wireless Web applications suppose challenges like:

- Device proliferation
- Bandwidth and interface limitations
- Applications with limited capabilities
- Emerging wireless standards.

The development of the physical components and software necessary to implement the Intelligent Web requires compatibility, integration, and synergy of the following five emerging technology areas:

1.User interface - transition from the mouse click and keyboard to speech as the primary (but not exclusive) method of communication between people and devices;

2.Personal space - transition from connection of devices by tangled wires to multifunction wireless devices;

3.Networks - transition from a mostly wired infrastructure to an integrated wired/wireless system of interconnections;

4.Protocols - transition from the original IP to the new Mobile IP;

5.Web architecture - transition from dumb and static applications to new applications that are intelligent, dynamic, and constantly learning.

As the Web matures, the information technology community seems to be viewing the Web as a global database with a knowledge representation system. Although a database management system is simply a collection of procedures for retrieving, storing, and manipulating data, it is also possible to view the Web in terms of applied learning algorithms in which data is taken from a database as input and, after appropriate algorithmic operations (based upon statistics, experiment, or other approaches) are performed, an output statement is returned that contains enhanced data, thereby representing a form of learning. The Intelligent Web will be a Web that learns, yielding continuously improved applications and information.

2 The Intelligent Web Framework

2.1 User Interface

The need to efficiently provide information to machines, control their functions, and receive information from them to inform human operators of their status has increased dramatically over many decades. Although the language is the primary means of human communication, communication through language has many obstacles, from the simple and obvious differences between the tongues spoken in different countries to the "untranslatable" slang differences between cultures. And, even for a healthy listener, background noise can make normal speech perception difficult.

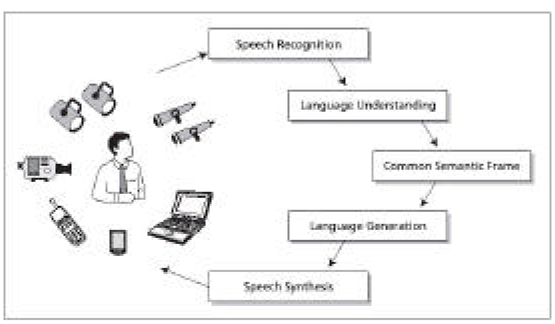

Fig. 1. The communication process

The human voice is unique to each individual (no two people have exactly the same voice) and many words that sound alike have a different spelling or meaning. Minor differences in meaning can lead to major misunderstanding of language. Nuances of meaning can frequently be interpreted only by considering overall context. These problems present challenges for speech recognition software and speech-enabled applications.

2.2 Personal Space

The Personal Space is the immediate vicinity that can be visually inspect around. Wireless technology offers connectivity among devices within Personal Space without "cable tangle" around both at the office and at home.

In the year 2000, there were over 15 billion devices of various types worldwide and 30 percent of all communication was actually conducted as device to device. By 2010, 95 percent of all communication will be between devices.

Device-to-device communication must become more efficient and intelligent in order to increase productivity. The next generation of networking will be Web-centric but with the introduction of the mobility factor, extending to devices such as wireless phones or PDAs. The convergence of wireless networks and the Internet can be made through standards and advances in computing and communications technologies. The model extends the Enterprises' reach to a disparate range of devices, such as wireless phones, PDAs, pagers, LAN phones, automobile PCs, and cable television.

In a wireless network with many mobile devices, channel conditions vary unpredictably over time. Running a variety of applications over a network introduces significant variability in required bandwidth, error rate, and security. For example, electronic-commerce (e-commerce) applications require encryption, whereas an entertainment application may not.

Conventional network interfaces are inflexible. They are designed to operate under the worst conditions, rather than to adapt to changing conditions. This leads to inefficient use of spectrum and energy. The problems range from wires and connectors to operating systems (OSs) with annoying incompatibility and difficult component integration. Currently, wireless standards for connecting local devices are competing for dominance. The three near-term standard leaders are

Bluetooth, Jini, and Universal Plug and Play (UPnP).

2.3 Networks

During the subsequent decades, mergers, takeovers, and downsizing have led to a need to consolidate company data in fast, seamless, integrated databases for corporate information. Intranets and local networks began to increase in size, and this required new ways for devices to interface with each other.

Over the past decade, enterprise models and architectures, as well as their corresponding implementation in actual business practices, have changed to take advantage of new technologies. Network computing has become the means to increased efficiencies in knowledge management - systematically finding, selecting, and organizing information. As knowledge management improves, employees, partners, and customers become better connected within an enterprise. As a result, mundane tasks can be easily relegated to computers while corporations focus on more important tasks.

For corporations that are heavily invested in legacy systems, however, deploying new wireless applications could mean that they must find a way to build on the existing infrastructure.

Networks are built upon three necessary elements that must be balanced:

1. Bandwidth

2. High-speed switching

3. Network intelligence.

In spite of optical fiber developments, expanding bandwidth and the contest between IP packet switching verses asynchronous transfer mode (ATM) circuit switching, network intelligence is only recently showing its importance. Intelligent Networking is a concept that is leading to new technological development, as user demands become more sophisticated. It is more than just network architecture: it is a complete framework for the creation, provisioning, and management of advanced data transmission services.

2.4 Protocols

Over the years, various players in the market have defined several protocols for various types of applications (Handheld Device Markup Language - HDML, Nokia's Tagged Text Markup Language – TTML, Ericsson's Intelligent Terminal Transfer Protocol – ITTP). This fragmentation limited the market growth for wireless applications so that forces were joined in defining a common platform and protocol and embracing Internet access and messaging.

The first joint meeting to consider wireless standards took place in June 1997. The intention was to broaden the group of companies working with the Wireless Application Protocol (WAP). In December 1997, WAP Forum Ltd. developed WAP. WAP is designed to provide data-oriented (nonvoice) services any time and anywhere.

The WAP microbrowser can be compared to a standard Internet browser. The applications must be written in the new markup language defined within WAP, named Wireless Markup Language (WML). WML is structured rather similarly to HTML.

In addition to specialized protocols, such as WAP, Internet Protocols themselves are undergoing transition. The Mobile IP Working Group of the Internet Engineering Task Force has developed routing support to permit IP nodes (hosts and routers) using either IP version 4 (IPv4) or IPv6 to seamlessly "roam" among IP subnetworks and media types. The Mobile IP method supports transparency above the IP layer.

Normally, IP routes packets from a source to a destination by allowing routers to forward packets from incoming to outbound network interfaces in accordance with routing tables. The routing tables maintain the next-hop (outbound interface) information for each destination IP address. The network number is derived from the IP address. To maintain existing transport-layer connections as the mobile node moves from place to place, it must keep its IP address the same. However, in Transmission Control Protocol (TCP), the connection is indexed by a quadruplet IP address with port numbers for both endpoints. Changing any of the four numbers will cause the connection to be lost. The problem is that delivery of packets to the mobile node's current point depends on the network number contained within the mobile node's IP address, which changes at new points of attachment.

Mobile IP has been designed to solve this problem by allowing the mobile node to use two IP addresses. In Mobile IP, the home address is static to identify TCP connections. The “care-of” address changes at each new point of attachment and can be thought of as the mobile node’s topologically significant address. This address shows the network number and identifies the mobile node’s point of attachment. Whenever the mobile node is not attached to its home network, the home unit gets all the packets destined for the mobile node and delivers them to the mobile node’s current point of attachment. Whenever the mobile node moves, it registers its new “care of” address with its home unit. The home unit delivers the packet from the home network to the care of address.

2.5 Web Architecture

For the Web to learn, it requires learning algorithms and mechanisms for self-organization of a hypertext network. It needs to develop algorithms that would allow the Web to autonomously change its structure and organize the knowledge it contains, by “learning” the ideas and preferences of its users.

One way to move toward these goals has been suggested by W3C through the use of better semantic information as part of Web documents and of the use of next-generation Web languages such as XML and RDF. The Semantic Web Architecture will enable movement from IP to Mobile IP in addition to providing an XML layer, an RDF schema layer, and a logic layer.

Facilities to put machine-understandable data on the Web are becoming a high priority for many communities. Tomorrow’s programs must be able to share and process data even when designed totally independently. The Semantic Web is one vision of having data on the Web defined and linked in a way that it can be used by machines not just for display purposes but for automation, integration, and reuse of data (figure 2).

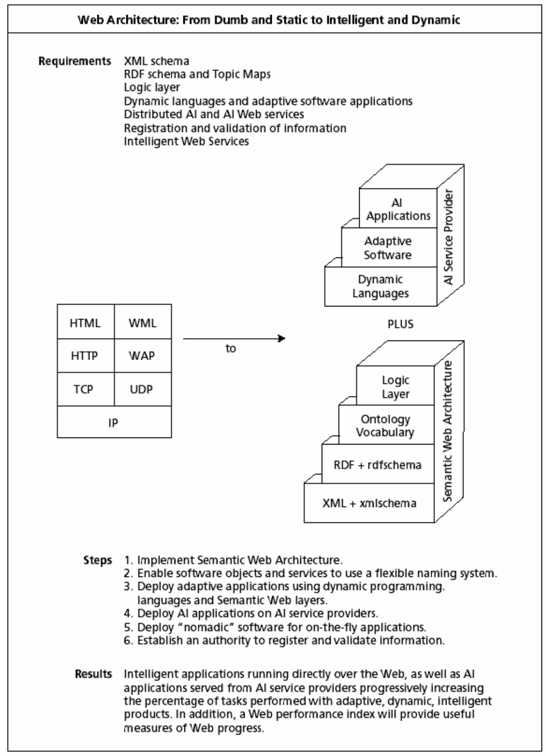

Fig. 2. Transitioning Web architecture

An alternative to the Semantic Web is the successful development of Intelligent Web Services through Microsoft Net and Java2 Enterprise Edition (J2EE).

The key needs that will enable transition from the current dumb and static systems to the intelligence and flexibility of the Intelligent Wireless Web are: Semantic Web, XML schema, RDF schema, logic layering, and distributed AI and AI service providers. In addition, information registration and validation will be an essential global service to support activities such as financial transactions.

2.6 Self-Organizing Software and Adaptive Protocols

Traditional software development was based on principles such as exact specification, complex maintenance, and high levels of abstraction. Today software is expected to do more because of our increasingly complex environments (the complexity comes from users, systems, devices, and goals). Programmers are accustomed to a trade-off of time versus memory. Now they have to worry about bandwidth, security, quality of

information, resolution of images, and other factors.
The problems with existing software are that it takes too much time and money to develop and it is brittle when used in situations for which it was not explicitly designed. Various software design methodologies can alleviate this problem.
The Web needs a significantly higher degree of dynamism and mobility, as well as a robust network infrastructure and protocols. Self-organizing software, adaptive protocols, and object-oriented dynamic languages can provide the Web with the tools it needs to learn.
Self-organizing software means the ability of networks to organize and configure themselves. Adaptation means the ability of protocols and applications to learn and adapt to the changing conditions in the network, such as levels of congestion and errors. The next generation of programming languages will support intelligent, adaptive, complex software systems. “Reflection,” or reasoning, will be built into the language’s own structure, performance, and environment, along with support for dynamic modification of behavior. Adaptive software will use information from the environment to improve its behavior over time.
Today, adaptive programming is aimed at the problem of producing applications that can readily adapt in the face of changing user needs and environments. Adaptive software explicitly represents the goals that the user is trying to achieve. This makes it possible for the user to change goals without a need to rewrite the program.
A typical application is an information filter. Adaptive software adds a feedback loop that provides information based on performance. The design criteria itself becomes a part of the program, and the program reconfigures itself as the environment changes.
Static languages, such as C, require the programmer to make a lot of decisions about structure and the data. Object-oriented dynamic languages form a higher level of abstraction and reflection. MIT’s Dynamic Language (Dylan) and Common Lisp Object System (CLOS) allow these decisions to be delayed and thus provide more responsive programming.

The Internet should be viewed in terms of information instead of data packets. Instead of establishing TCP connections to some server, think of the device as a client of the information, rather than a client of the server. It becomes a distributed application that is running on some machine that requires some functionality or some service that exists somewhere in the network. As a result, large networks have a set of consumers and a set of providers of information. The network task is to match consumers and providers (one way to accomplish this is through the use of Intelligent Web Services or AI service providers).
Second, the network becomes efficient by learning about conditions on the network, such as changes in bandwidths, error conditions, and failure modes. And, finally, it begins to adapt.
Adaptive protocols can achieve this when they become a core component in the future Internet infrastructure. They will enable distributed applications that can be designed to organize themselves. Deployable intelligence mechanisms can be associated with Learning Algorithms, including pattern recognition algorithms and data mining algorithms. Different applications can reuse the same algorithm-level software. It is important to be able to guide the automation process and to override decisions. Software areas under development include:

- Agent technology acting for a user’s preferences
- Data mining
- Decision theory providing terminology for expert systems for preferred outcomes
- Reinforcement learning finding actions to perform
- Probabilistic networks providing algorithms for computing optimal actions
- Expert systems: Computer applications making decisions in real-life situations that would otherwise be performed by a human expert
- Neural networks: Systems simulating intelligence by reproducing the types of physical connections found in animal or even human brains

Major research challenges are ahead in expanding intelligence offered as Web Services. The first is the problem of scaling to large networks and to large numbers of applications.
The second issue is an end-to-end adaptation framework with underlying layers of the protocol stack to applications. This will allow learning about what's going on in the network and enabling new algorithms and new protocols to react.

3. The Semantic Web and Intelligent Web Services (Case Study)

The semantic Web aims to add machine-processable information to the largely human-language content currently on the Web. Web Services represent a similar concept aimed at sending machine-processable information between organizations in an attempt to automate processes. XML Web services provide programmable components remotely. They allow access to services provided by us, Microsoft, or a third party. Example of Web Services include services supporting *meaningful content-based discovery of information sources*, *e-marketplaces* (for example, auction houses), *fusion of information from multiple sites*, *convenient querying by users* (for example, using natural language), *the integration of conventional office workflow with Web publishing*,
XML Web services differ from previous proprietary solutions:

- They are platform independent and language independent; programs written in any language (not just the .NET languages) and running on any platform can use them;
- They are based on existing, open protocols such as HTTP, SOAP, and XML;
- Unlike other remote access methods, XML Web services can navigate Internet firewall.
- Using XML as a means to communicate data between a client and an XML Web service further enhances this powerful component architecture.

One key deployment area for Web Services is e-business. E-business is intrinsically task-based: participants engage in activities such as advertising, brokering, buying and selling. Such activities can be defined as Web Services, allowing both end users and software agents to invoke them directly. The interface to these Web Services might be configured to support different user characteristics – for example, mobile users or users requiring speech access.

The Semantic Web initiative's purpose is similar to that of Web Services: to make the Web machine-processable, rather then merely "human browsable". Key components of the Semantic Web technology are:
1. a unifying data model such as RDF (Resource Description Framework)
2. languages with defined semantics, built on RDF, such as DAML+OIL (DARPA Agent Markup Language plus Ontology Inference Layer)
3. ontologies of standardized terminology for marking up Web resources, used by semantically rich service-level description, and support tools that assist the generation and processing of semantic markup.

The Web Services are an essential ingredient of the Semantic Web and benefit from Semantic Web technology.

We have built a multiagent system, called **B**uyer **S**eller **A**gents. It has two types of agents that facilitate price negotiations between buyers and sellers. They have the characteristics of intelligent agents: reactivity – they perceive their environment and respond; proactivity – they exhibit goal-directed behavior; and social character – they interact with other agents.
We have also used the .NET Framework tools to add mobile access to our BSA system. We developed two XML Web services that handle communication with buyer and seller agents.
Web services written for ASP.NET have access to the Session and Application objects, which maintain both application and session state for your XML Web service.
XML Web services built with ASP.NET can manage their state. Like any other ASP.NET application, an XML Web service provides access to both the Session object and the Application object. HTTP is effectively a stateless protocol. ASP.NET overcomes this problem by storing data on the server that relates either to an individual session or to an appli-

cation as a whole. We can store data that relates to a user's interactions with a given agent (buyer or seller) in the Session object, and we can store data common to all agents in the Application object.

Fig.3. Output of the mobile Web application that consumes the buyer XML Web Service

We see that the buyer agent (through the XML Web Service) recommend seller V2 as the best offering for an Athlon XP 1700 MHZ processor.

Conclusions

The Intelligent Web provides automated information access based-on machine-processable semantics of data and heuristics that use the metadata. The explicit representation of the semantics of data, accompanied with domain theories (ontologies), will enable the Web to provide a qualitatively new level of service. It will weave together an incredibly large network of human knowledge and will complement it with machine processability. Various automated services will help the user to achieve goals by accessing and providing information in a machine-understandable form. This process might ultimately create an extremely knowledgeable system with various specialized reasoning services – systems that can support us in nearly all aspects of our life.

References

1. Alesso H. P., Smith C. F. – "*The Intelligent Wireless Web*", Addison Wesley, 2002
2. Berners-Lee T, Hendler J., Lassila O – "*The Semantic Web*", Scientific American, 2001, http://www.sciam.com/
3. Leon F. – "*Stadiul actual al cercetarilor în domeniul agentilor inteligenti*", www.cs.tuiasi.ro
4. Wigley A., Roxburgh P. – "*Building .NET Applications for Mobile Devices*", Microsoft Corporation, 2002
5. Preece A., Decker S. – "*Intelligent Web Services*", IEEE Intelligent Systems, January/February, 2002
6. Fensel D., Musen M. – "*The Semantic Web: A Brain for Humankind*", IEEE Intelligent Systems, March/April, 2001
7. Hendler J. – "*Agents and the Semantic Web*", IEEE Intelligent Systems, March/April, 2001