# Allied Data Publication 34

# (ADatP-34(D))

# NATO Interoperability Standards and Profiles

## Volume 3

# Mid Term

**Date: 12 January 2010**

**C3 CCSC NATO Open Systems Working Group**

# Table of Contents

This page is intentionally left blank

# 1. INTRODUCTION

001. This document has been developed and agreed (AC/322(SC/1-WG/4)N(2010)0002-AS1, 24 Mar 10) by the NATO Open Systems Working Group (NOSWG) under the authority of the NATO Consultation, Command and Control Board (NC3B). Under AC/322-N(2010)0038-AS1, the NATO Consultation, Command and Control Board noted ADatP-34(D) and approved the standards and profiles in Volume 2 as mandatory for use in NATO common funded systems in accordance with the NATO networked C3 Interoperability Policy.

002. NATO Network-Enabled Capability (NNEC) aims to provide an environment where connected collectors, decision-makers, effectors, and information sources are integrated in a common network of networks and can be provided with, search for, or supply data and information from any location under user-adapted format and within user relevant time constraints. Advantage is taken of the great advances within civilian information and communication technology. Solutions under network-oriented concept are based on:

- Service-Oriented Architecture (SOA)
- Federation of systems, including federated networks.
- Situation adapted combinations of units and systems

**Figure 1.1. NNEC Concept**

003. Volume 3 of this NISP will continue the evolution from the platform based NCOE to the loosely coupled Network Enabled Capabilities environment where the functionality of the

interconnected systems is made generally available as "services on the net". Ultimately the goal is that all systems shall be connected. By means of real time configuration of interacting systems, it is possible to combine the functionality of the most useful systems in each situation.

004. Within this part of the document, the focus is on the mid-term's perspective. The mid-term perspective has a time frame of 2 to 6 years into the future from the publication of this version of the NISP. This is the intermediate step to the realisation of a fully network enabled NATO coalition environment.

# 2. MID-TERM EMERGING TECHNOLOGIES AND STANDARDS

005. The purpose of this section is to identify a number of key emerging (commercial) technologies that are relevant to NATO and to provide a useful level of analysis about their possible application within military systems. While the emerging technologies discussed in this section are not exhaustive, the content of this section does draw significantly upon the technology tracking efforts of the NOSWG member nations. Once technologies are identified and their applicability analysed, then informed decisions can be made on what role each technology or standard will play in the current technical architecture. The rapid pace of technological change carries with it the potential benefits of faster and more cost-effective improvements in operational capability; however, the rapidity of change upon a broad technology front also makes the task of identifying emerging technologies particularly difficult.

006. The intention of this element of the NISP volume 3 is to be informative, whilst maintaining brevity, on a range of technologies. Consequently, the information is presented as a series of short articles that cover the essential points of interest. This flexible format is intended to facilitate the rapid change of content that will inevitably happen between issues of the NISP.

## 2.1. COMPUTING

007. Computing is usually defined as the activity of using and developing computer technology, computer hardware and software. It is the computer-specific part of information technology.

### 2.1.1. Programming Languages

008. A programming language is an artificial language designed to express computations that can be performed by a machine. Programing languages have written specifications of their syntax and specification.

#### 2.1.1.1. F Sharp (F#)

009. Developed by Microsoft, F# is a strongly-typed language that uses type inference. As a result, data types need not be explicitly declared by the programmer; they will be deduced by the compiler during compilation. However, F# also allows explicit data type declaration. Being a .NET language, F# supports .NET types and objects. But it extends the type system and categorizes types as immutable types or mutable types. .NET objects classify as mutable types (which can be edited in-place), and are used to provide an object-oriented programming model. Immutable types (editing which creates a new instance without overwriting the older one) are primarily used for functional programming.

010. **Status**: Now being transitioned towards a fully supported language on the .NET platform.

# 2.2. COMMUNICATIONS & NETWORKING

## 2.2.1. Disruption Tolerant Networking (DTN)

011. Disruption Tolerant Networking (DTN) are comprised of technologies that will provide network services when no end-to-end path exists through the network because of periodic or intermittent disruptions. Disruption may occur because of the limits of wireless radio range, sparsity of mobile nodes, energy resources, enemy attack, and noise. Such a robust communications network would have to be autonomic, secure and opportunistic.

012. **Implications**: The research in this area is principally aimed at providing internet-like services and supporting "long-haul" reliable transmission in interplanetary space, but it has applications in other environments as well. The work done to overcome delays caused by interplanetary distances can easily be appealed to tactical military networks. Distance delays are just a subset of the more general group of Disruption sources.

### 2.2.1.1. Bundle Protocols

013. Research goals in this area are to provide disruption tolerance by organizing information flow into bundles. These bundles are to be routed through an "intelligent" network that can manage the delivery of the bundles to the maximal extent permitted by the available topology. This method will allow messages to pass through the network with successive responsibilities, rather than the traditional end-to-end scheme. The mechanism of bundling will allow a network node to hold data if the next hop in the network is unavailable.

014. **Status**: The Internet Engineering Task Force (IETF) has recently published RFC 4838 and RFC 5050 to provide the common defining framework for the formation and transport of bundles of data. In 2008, the Bundle Protocol was successfully tested in space on the UK-DMC Disaster Monitoring Constellation satellite.

### 2.2.1.2. Licklider Transmission Protocol (LTP)

015. The Licklider Transmission Protocol (LTP) was designed to provide retransmission-based reliability over links characterized by extremely long message round-trip times (RTTs) and/or frequent interruptions in connectivity.

016. The Licklider Transmission Protocol (LTP) would replace both IP and TCP. Picturing protocols as layers in a stack, if the bottom layer is the physical wire line or radio wave connecting two devices, the Licklider Transmission Protocol sits just above that. It makes the link between two routers more reliable than IP and TCP.

017. **Status**: In 2008, the IRTF Working Group of the IETF established an experimental RFC (RFC 5326) on this topic

## 2.2.2. Wireless Networking

018. Several wireless network standards have been developed to encompass the wide range of mobile environments and applications.

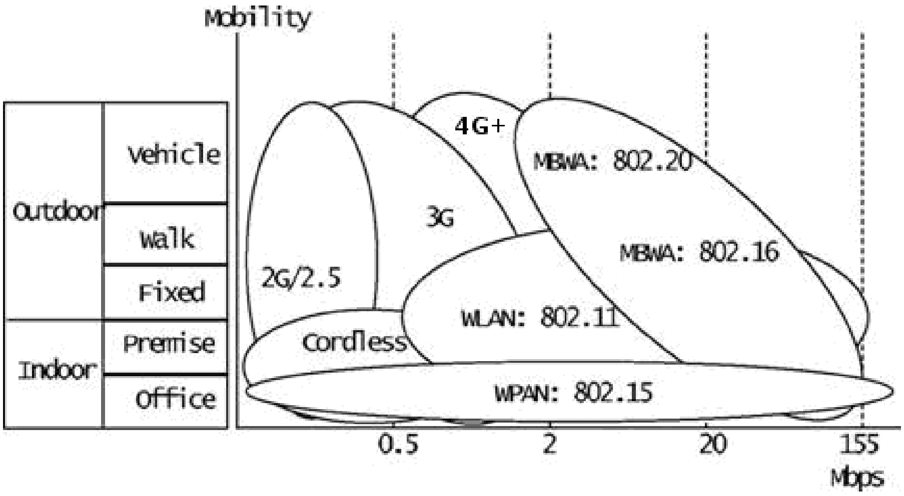


**Figure 2.1. Standards, Mobility, and Data Rates**

### 2.2.2.1. Wireless Personal Area Network (WPAN)

019. A wireless personal area network (WPAN) is a computer network used for communication among computers, I/O peripherals (such as keyboards, printers, scanners, etc) and devices (such as wireless access points, cell phones and personal digital assistants) within reach of a person. The devices may or may not belong to the person in question. The range of a WPAN is typically less than 10 metres, and up to 1 kilometre under ideal conditions. WPANs can be used to replace cables between computers and their peripherals, to establish communities, or to establish location aware services. WPANs can be used for communication among the personal devices themselves (intra-personal communication), or for connecting to a higher level network and the Internet (an up link).

| Standard | Frequencies | Spectrum Type | Data Rates |
|---|---|---|---|
| Bluetooth | 2.4GHz | Unlicensed ISM | 2.1 Mbit/s |
| Wibree | 2.4GHz | Unlicensed ISM | 1 Mbit/s |
| ZigBee | 868 MHz, 915 MHz, 2.4GHz | Unlicensed ISM | 40-250 kbit/s |
| Wireless USB, UWB | 5GHz+ | Unlicensed UWB | 250 kbit/s |

**Table 2.1. PAN Summary**

020. **Importance**: A key concept in WPAN technology is known as plugging in. Ideally, when any two WPAN-equipped devices come into close proximity (within several metres of each other) or within a few kilometres of a central server, they can communicate as if connected by a cable. Another important feature is the ability of each device to lock out other devices selectively, preventing needless interference or unauthorised access to information.

021. **Implications**: Collaboration between units in the same physical area is possible. Useful on the battlefield as a method for soldier communications and monitoring.

## 2.2.2.1.1. IEEE 802.15.1 (Bluetooth 3.0)

022. The next version of Bluetooth, currently code named , includes a number of features to increase security, usability and value of Bluetooth. The following features are defined:

- Atomic Encryption Change - allows encrypted links to change their encryption keys periodically, increasing security, and also allowing role switches on an encrypted link.
- Extended Inquiry Response - provides more information during the inquiry procedure to allow better filtering of devices before connection. This information includes the name of the device, and a list of services, with other information.
- Sniff Sub-rating - reducing the power consumption when devices are in the sniff low power mode, especially on links with asymmetric data flows. Human interface devices (HID) are expected to benefit the most with mice and keyboards increasing the battery life from 3 to 10 times those currently used.
- QoS Improvements - these will enable audio and video data to be transmitted at a higher quality, especially when best effort traffic is being transmitted in the same piconet.
- Simple Pairing - this improvement will radically improve the pairing experience for Bluetooth devices, while at the same time increasing the use and strength of security. It is expected that this feature will significantly increase the use of Bluetooth.

023. Bluetooth technology already plays a part in the rising Voice over IP (VoIP) scene, with Bluetooth headsets being used as wireless extensions to the PC audio system. As VoIP becomes more popular, and more suitable for general home or office users than wired phone lines, Bluetooth may be used in Cordless handsets, with a base station connected to the Internet link.

024. The version of Bluetooth after , code-named , has many of the same features, but is most notable for plans to adopt Ultra-wideband radio technology. This will allow Bluetooth use over UWB radio, enabling very fast data transfers, synchronisations and file pushes, while building on the very low power idle modes of Bluetooth. The combination of a radio using little power when no data is transmitted, and a high data rate radio used to transmit bulk data, could be the start of software radios. Bluetooth, given its worldwide regulatory approval, low power operation, and robust data transmission capabilities, provides an excellent signalling channel to enable the soft radio concept.

025. **Status**: On 28 March 2006, the Bluetooth Special Interest Group (SIG) announced its selection of the WiMedia Alliance Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) version of Ultra-wideband (UWB) for integration with current Bluetooth wireless technology. UWB integration will create a version of the globally popular Bluetooth wireless technology with a high speed/high data rate option. This new version of Bluetooth technology will meet the high-speed demands of synchronising and transferring large amounts of data as well as enabling high quality video and audio applications for portable devices, multi-media projectors and television sets, wireless VoIP. At the same time, Bluetooth technology will continue catering to the needs of very low power applications such as mice, keyboards and mono headsets, enabling devices to select the most appropriate physical radio for the application requirements, thereby offering the best of both worlds.

## 2.2.2.2. Wireless Local Area Network (WLAN)

026. A wireless local area network (WLAN) is the linking of two or more computers without using wires. WLAN utilises spread-spectrum technology based on radio waves to enable communication between devices in a limited area, also known as the basic service set. This gives users the mobility to move around within a broad coverage area and still be connected to the network.

027. **Importance**: Wireless Local Area Networks are more convenient, mobile, deployable, expandable, and cheaper than wired networks.

028. **Implications**: The wireless nature of such networks allows users to access network resources from nearly any convenient location within their primary networking environment. Initial setup of an infrastructure-based wireless network requires little more than a single access point. Eliminates the cost, time, and labour of running physical cables.

### 2.2.2.2.1. IEEE 802.11 (WiFi)

029. Many are familiar with 802.11, also known as WiFi, as a short-range wireless networking protocol for home and office connections. 802.11 represent a family of wireless standards. The 802.11 series has been developed by the IEEE over the past 10 years as part of the range of communications protocols under the 802 standards series.

030. Each family member is identified by a letter suffix to the series name. Currently these letters run from "a" to "w", although there is the original base 802.11 wireless standard as well. Note that there is no L standard. Some family members represent amendments (a, b, g, i) to the original standard, whereas some represents enhancements or extensions (c-f, h-j, n).

031. The 802.11 family of protocols share two common frequency bands, 2.4GHz and 5GHz, the so-called Industrial, Scientific and Medical (ISM) bands. Further more, each of these bands are divided into 14 channels. The availability of channels is regulated by nation, constrained in part by how each nation allocates radio spectrum to various services. At one extreme, Japan permits the use of all 14 channels (with the exclusion of 802.11g/n from channel 14), while at the other Spain allowed only channels 10 and 11 (later all of the 14 channels have been allowed ), to which

France adds 12 and 13. Most other European countries are almost as liberal as Japan, disallowing only channel 14, while North America and some Central and South American countries further disallow 12 and 13. The emerging standards within the 802.11 family are as follows:

032. **802.11-2007**: Consolidated amendments 802.11a,b,d,e,g,h,i,j with the original base standard to form the latest base standard. **Status**: Approved as standard in March of 2007.

033. **802.11k**: Intended to improve the way traffic is distributed within a network by discovering the best available access point. In a wireless , each device normally connects to the access point (AP) that provides the strongest signal. Depending on the number and geographic locations of the subscribers, this arrangement can sometimes lead to excessive demand on one AP and underutilisation of others, resulting in degradation of overall network performance. In a network conforming to 802.11k, if the AP having the strongest signal is loaded to its full capacity, a wireless device is connected to one of the underutilised APs. Even though the signal may be weaker, the overall throughput is greater because more efficient use is made of the network resources. 802.11k and 802.11r are the key industry standards now in development that will enable seamless Basic Service Set (BSS) transitions in the WLAN environment. **Status**: Still in draft form, but expected to be ratified in 2008.

034. **802.11n**: Focuses on improvements on the 802.11 standard to obtain data throughput of at least 100Mbps, improved coverage, and longer range. Such advances will be achievable through multiple-input/multiple-output (MIMO) communication. MIMO uses multiple radios simultaneously transmitting and receiving different signals to and from at least two radios on the client side to and from two or more on the access point. **Status**: Expected to be ratified in 2009. There are still some interoperability issues. There are many products available based on the pre-draft standard.

035. **802.11p**: "Wireless Access in Vehicular Environments (WAVE)" - Wireless communication between fast moving vehicles or between a fast moving vehicle and a stationary object. This standard supports speeds of minimum of 200km/h and ranges of up to 1km. It uses 850-5.925 GHz band and defines enhancements to 802.11 required to support Intelligent Transportation Systems (ITS) applications. The vision is for nationwide network that enables communications between vehicles and roadside access points or other vehicles. Such networks would enable toll collection, vehicle safety services, and commerce transactions via cars. **Status**: Expected to be ratified in 2009. This standard would be the foundation for projects like the Communications, Air-interface, Long and Medium range (CALM) system in Europe, and Dedicated Short Range Communications (DSRC) in the United States.

036. **802.11r**: "Fast Roaming" - This proposed standard will specify fast Basic Service Set (BSS) transitions that address the faster transfer of a station from one access point to another. Faster transitions are essential to support real time applications such as VoIP ("voice over IP", or Internet-based telephony) via mobile phones designed to work with wireless Internet networks, instead of (or in addition to) standard cellular networks. This will permit connectivity aboard vehicles in motion, with fast handoffs from one base station to another managed in a seamless manner. Handoffs are supported under the "a", "b" and "g" implementations. **Status**: Ratified and published in July of 2008.

037. **802.11s**: "Mesh Networking" - Wireless Distribution System (WDS) protocol that is able to auto-configure paths between APs. **Status**: ???

038. **802.11u**: "Inter-working with External Networks" - The primary focus is on inter-working with cellular networks. **Status**: Ongoing; still being evaluated.

039. **802.11v**: "Wireless Network Management" - Management (monitoring, configuring, updating) of attached stations through layer 2. It is to complement 802.11k that gathers information from the stations.

040. **802.11y**: "3650-3700 MHz Operation in the U.S# - This amendment to 802.11-2007 would allows WiFi "like" equipment to operate at higher power levels with a range of up to 5 kilometres in the United States. It introduces three new concepts to the 802.11-2007 standard: Contention Based Protocol, Extended Channel Switch Announcement, and Dependent Station Enablement. Even though the current form is specific to operations in the United States, care was taken so that, if the light licensing concept was well received, it would not be necessary to start the 3+ year task group process in order for 802.11y devices to operate in other countries or in other frequency bands. As a result, lightly licensed 802.11 devices will be able to operate in any 5, 10, or 20Â MHz channel that regulators make available by simply adding entries to the country and regulatory information tables in Annex I and J of 802.11. Has implications in the following areas: Back haul for Municipal Wi-Fi networks, Industrial automation/controls, Campus/Enterprise networking, Last Mile Wireless Broadband Access, Fixed Point to point links, Fixed point to mobile links, and Public safety and security networks. **Status**: Submitted for approval in June of 2008; Still not ratified.

| **Standard** | **Description** | **Status** |
|---|---|---|
| IEEE 802.11k | Radio resource measurement enhancements | Ongoing |
| IEEE 802.11n | Higher throughput improvements (e.g. MIMO) | Ongoing. Estimated ratification in 2009 |
| IEEE 802.11p | WAVE -Wireless Access for the Vehicular Environment (such as ambulances and passenger cars) | Ongoing. Estimated ratification in 2009. |
| IEEE 802.11r | Fast roaming | Ratified in July of 2008 |
| IEEE 802.11s | EWireless mesh networking | Ongoing |
| IEEE 802.11t | Wireless Performance Prediction (WPP) -test methods and metrics | Ongoing |
| IEEE 802.11u | Inter-working with non-802 networks (e.g., cellular) | Ongoing |
| IEEE 802.11v | Wireless network management | Ongoing |
| IEEE 802.11w | Protected Management Frames | Ongoing |
| IEEE 802.11y | 3650-3700 Operation in USA with wide range | Ongoing. Estimated ratification in 2009. |

**Table 2.2. Emerging 802.11x Summary**

## 2.2.2.3. Mobile Broadband Wireless Access (MBWA)

041. While many military installations have some sort of high-speed network backbone connected by fibre optic cabling, many of the buildings do not have high-speed connections to the backbone. This is because fibre-optic cabling, necessary for most high-speed communications, must first be installed in the ground.

042. Three emerging mobile data architectures have the most promise to eliminate the need for cables. In an effort to further improve mobile technology bandwidth, the IEEE 802 standards group which is already developing 802.11 (Wireless , WLAN), 802.15 (Personal Area Networks, PAN), 802.17 (Fixed Broadband Wireless Access, FBWA) has turned its attention to a new standardisation efforts on mobile broadband wireless access (MBWA).

043. As with many civil based technologies the key question is likely to be the performance of the system under stress (e.g. Interference/jamming). However, there exists a possibility of a low cost wireless network offering all IP connectivity for easy integration with other component networks, rapid base-station deployment, basic network security (allowing higher security to layer on top) and high performance to many users.

044. **Importance**: Installing fibres is a disruptive, costly and time-consuming process. Trenching costs become prohibitive to reach remote areas, such as transportation depots and ranges. Also, right-of-way issues and physical barriers such as lakes and historical grounds can increase the cost of installing fibre-optic cabling.

045. **Implications**: In the tactical world, MBWA may be well suited for quickly establishing links between temporary camps, command centres, and vehicles.

| **Characteristics** | | **Mobile Data Architectures** | | | |
|---|---|---|---|---|---|
| | | **802.16e** | **802.20** | **HiperMAN** | **4G+** |
| Standard Type | | Open | Open | Open | Open |
| Cell Radius | Line-of-sight | 48 km | - | 10 km | - |
| | Non Line-of-sight | 3 km | - | 4km | - |
| Cell Speed | | 60 miles/hr | 250 km/hr | - | - |
| Data Rate | Moving | < 10 Mbps | - | - | 280 Mbit/s |
| | Stationary | 10 Mbps | - | 14 Mbit/s | 1 Gbit/s |
| | Peak | 70 Mbps | 1 Mbps | 63 Mbit/s | - |
| Spectrum | | < 6 GHz | - | 5.725-5.875 GHz | - |
| Architecture | | Packet | Packet | Packet | Packet/Circuit |

| | | | | | |
|---|---|---|---|---|---|
| Bands | | Selectable Between 2-6 GHz | Licensed Bands below 3.5 GHz | Selectable Between 2-11 GHz (Mainly 3.5 GHz) | Licensed Bands below 2.7 GHz |
| Latency | | Low | Low | High | High |

**Table 2.3. Data Architecture**

## 2.2.2.3.1. Mobile Telephone (4G+)

046. Although the new 3G systems (mobile phone companies have invested heavily in this technology) have just been launched not long ago, many companies have already started on researching and developing on the fourth generation (4G) system. Researchers are hoping that the 4G system can reach a much faster speed, a connection speed over 100Mb per second during connection, tighter network security and also bring up the quality during communication no matter on voice or video calls. Via mobile phones, many things such as the security system, surveillance on certain items could be done easily.

047. One 4G+ standardisation effort called Ultra Mobile Broadband (UMB) is being coordinated by 3GPP2 (Collaboration between five Asian and North American standards bodies. It will improve the CDMA2000 mobile phone standard for next generation applications and requirements. The proposed system intends to employ OFDMA technology along with advanced antenna techniques to provide peak rates of up to 280 Mbit/s. Goals for UMB include significantly improving system capacity, greatly increasing user data rates throughout the cell, lowering costs, enhancing existing services, making possible new applications, and making use of new spectrum opportunities. The technology will provide users with concurrent IP-based services in a full mobility environment.

048. **Status**: The UMB standardisation is expected to be completed in late 2007, with commercialisation taking place around mid-2009 or early 2010.

## 2.2.2.3.2. High Capacity Spatial Division Multiple Access (HC-SDMA, or iBurst)

049. The HC-SDMA interface provides wide-area broadband wireless data-connectivity for fixed, portable and mobile computing devices and appliances. The protocol is designed to be implemented with smart antenna array techniques to substantially improve the radio frequency (RF) coverage, capacity and performance for the system.

050. The HC-SDMA interface operates on a similar premise as GSM or CDMA2000 for cellular phones, with hand-offs between HC-SDMA cells reportedly providing the user with a seamless wideband wireless experience even when moving at the speed of a car or train.

051. **Status**: HC-SDMA is being incorporated by ISO TC204 WG16 into its standards for use of wireless broadband systems in the continuous communications standards architecture, known as CALM. The IEEE 802.20 working group had adopted a technology proposal that includes

the use of the HC-SDMA standard for the 625kHz Multi-Carrier Time Division Duplex (TDD) mode. Technology is available Asia, Europe, Africa, Middle East, and North America.

## 2.2.2.4. Ad-Hoc Networking

### 2.2.2.4.1. Mobile Ad-Hoc Networks (MANET)

052. A mobile ad-hoc network (MANET) is a self-configuring network of mobile routers (and associated hosts) connected by wireless links. The routers are free to move randomly and arbitrarily organise themselves. Accordingly, the topology of the wireless network may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. With attributes such as minimal configuration and quick deployment make ad hoc networks appropriate for situations like disasters (natural or man-made), medical emergencies, military conflicts, etc.

053. The earliest predate the Internet and were called "packet radio" networks. These early packet radio systems were part of the motivation of the original Internet Protocol suite. Current are designed principally for military utility; examples include Joint Tactical Radio System (JTRS) and the High-Capacity Data Radio (HCDR).

054. The widespread IEEE 802.11 ("WiFi") wireless protocol incorporates an ad-hoc networking system when no wireless access points are present, although it would be considered a very low-grade ad-hoc protocol by specialists in the field. The IEEE 802.11 system only handles traffic within a local "cloud" of wireless devices. Each node transmits and receives data, but does not route anything between the network's systems. However, higher-level protocols can be used to aggregate various IEEE 802.11 ad-hoc networks into .

### 2.2.2.4.2. Sensor Networks

055. A sensor network is composed of a large number of sensor nodes that are densely deployed either inside an area of operation or very close to it. The sensor nodes are tiny, low-cost, low-power, self-organising and multi-functional (sensing, data processing, and communicating). Since the sensor nodes can be random deployed, such networks are ideal in inaccessible terrains or disaster relief operations

| Characteristics | Sensor Networks | Traditional Ad-Hoc |
|---|---|---|
| Communication | Broadcast | Point-to-Point |
| Node Numbers | Large | Small |
| Node Density | High | Low |
| Node ID | None | Individual |
| Failure Rate | High | Low |
| Mobility | No | Yes |

**Table 2.4. Sensor vs. Ad-Hoc**

056. The differences between a sensor network and a traditional ad-hoc network can be seen in Table 2.4. The protocols and algorithms used in traditional ad-hoc networks do not work well with sensor networks primarily because of the relatively large number of sensor nodes used by sensor networks.

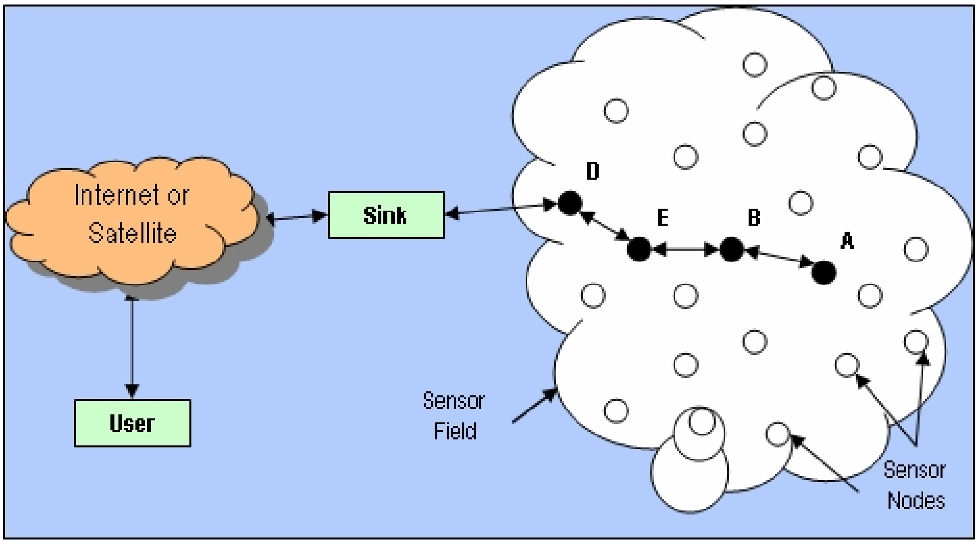


**Figure 2.2. Sensor Field**

## 2.2.2.5. Radio

### 2.2.2.5.1. Radio over Internet Protocol (RoIP)

057. Radio over IP is an method of converting analog radio signals into packets that transmited over an IP network. This capability of integrating disparate data and video signals with an IP infrasturcture could be the long disatnce hauler of short distance radio signals. With RoIP, there are no interoperability issues, all radio signals (e.g. VHF, UHF, POTS telephone, cellular telephone, SATCOM, air-to-ground) are packetized the same. Demodulation and detection of the orignal message is done after it has been transported.

058. **Status**: Draft standard is being developed by NIST, for the Bridging System Interface (BSI) hardware and software that enables radio gateway interoperability on a RoIP system. A half-dozen companies now offer Radio Over IP solutions. The tactical use of this technology has been demonstrated by coalition military forces in Afganistan and Iraq to protect convoys spread out across large geographic distances.

### 2.2.2.5.2. Radio Frequency Identification (RFID)

059. Radio Frequency Identification technology shares some similar characteristics with IP technology. IP is a remarkably flexible addressing system for information while RFID is a flexible addressing system for physical objects. RFID creates "an Internet of things" - a world of objects connected by Internet technologies. Indeed, it is possible that this new Internet of objects could significantly affect network architecture in the years to come.

060. RFID is the labelling system behind IP-enabled inventory and supply. Standard RFID tags contain three times the amount of information that can be stored in bar codes. They transmit data without contact or Line-of-sight with the reader, and can be read through dust, snow, ice, paint, or grime - conditions that render optical technologies, like bar coding, useless. Long-range tags can be read at speeds achievable by cars or trains, automated toll readers are a good example of this.

061. Capacitor / Coil (1) RFID reader Broadcasts electromagnetic signal to tag (4). The tag's coils release an encoded radio wave containing the information in the tag, which the reader then demodulates.(2) Antenna in the tag receives the signal from the reader and stores charge in a capacitor.(3) When the capacitor has built up enough energy, it releases it over time to the tag's coils.

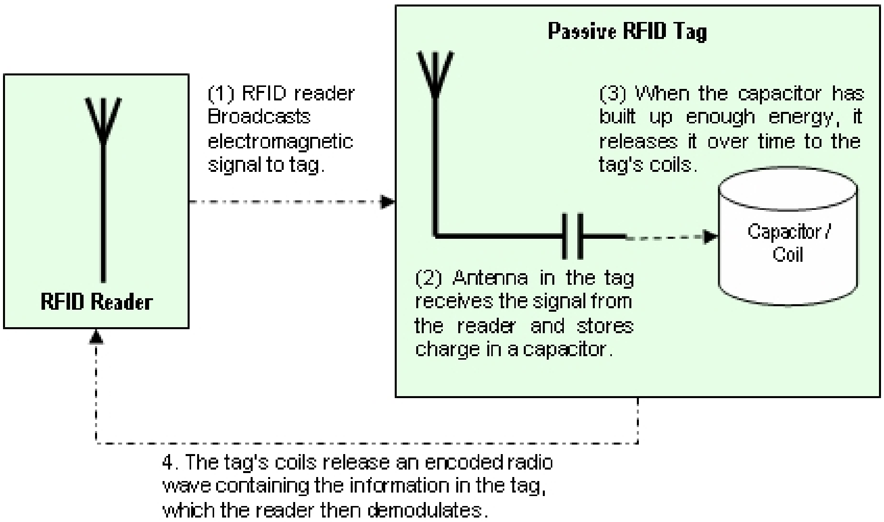


**Figure 2.3. RFID Example**

062. Most RFID tags are passive and read-only. With a virtually unlimited operating lifetime, they consist of little more than a computer chip and an antenna. A compatible reader provides power to the tag over short distances between a few centimetres to thirty meters. The tag 'awakens' and reports any information it has available to the reader. Active tags, on the other hand, are self-powered, have longer ranges than passive tags, and are constantly reporting relevant information to any reader within range. Active tags are becoming increasingly common, especially on expensive items, or cartons of items. A reader installed in a lock, for example, can automatically receive information from active tags in every vessel and shipping box that passes through. Additionally, some RFID tags are writable as well as readable.

063. Security is the key challenge with RFID. If a NATO nation implements RFID in its supply chain, and does not want other NATO nations to track its shipments and inventory, then that nation would perceive RFID technology as a significant security vulnerability.

064. Some researchers have proposed schemes that would require tags to authenticate readers, transmitting information only to authorised readers. The tags would have to store ID numbers for

authorised readers, and a reader would have to broadcast its ID to the tag. To protect the reader's ID and prevent others from eavesdropping and stealing the information, the reader uses either a fixed or randomly generated number to hash (encrypt) its ID. If the tag cannot authenticate the reader's identity, the tag will refuse to transmit the information it stores. Like most security tactics, this scheme is vulnerable to attacks, such as man in the middle, or reverse engineering.

065. **Importance**: An advanced way to automate the tracking of people and things.

066. **Implications**: Improved logistics through better management of supplies and inventories.

067. **Status**: Because of the potential market, several vendors are actively researching security and legacy integration issues. The big challenge to RFID is its integration into existing systems. Several vendors are developing RFID middle-ware that will link new RFID systems into existing back-end infrastructures. middle-ware, for example, can help with the current lack of standards in RFID. If an organisation picks a standard that changes or loses its market prevalence, middle-ware can transform the data from readers into the format supported by back-end systems.

## 2.2.2.5.3. Software Defined Radio (SDR)

068. Software Defined Radio (SDR) technology uses software to modulate and demodulate radio signals. This flexible approach would solve the problem of having to carry several types of special purpose radio. Ideally, one radio could can receive and transmit a new form of radio protocol just by running new software. All functionality and expandability is built upon the Software Communications Architecture (SCA), an international open architecture framework avaialble from the Object Management Group (OMG).

069. **Importance:** Reduces the need for troops to carry multiple radios.

070. **Implications**: Adaptable radios can solve cross-nation, and cross organisation communication interoperability problems.

071. **Status**: All the pieces needed to make this technology work in a tactical military environment are not ready. The biggest hurdles are form-factor, power consumption, and antenna size. Packaging such a radio that can handle every waveform used on a battlefield is daunting. Putting a 50 lb radio with a 30 foot antenna on the back of a foot solider is not practical.

## 2.2.2.5.4. Cognitive Radio Technology

072. Cognitive Radio technology is, when combined with Software Defined Radio technology, an effort to efficiently utilise the electromagnetic spectrum. The argument is that in any given region of the world, some portions of the spectrum are over utilised while some are underutilised. A cognitive radio will analyse the local spectrum and determine where there are spectrum "holes", or under-used spectrum. It is in these "holes" that the adaptive radio will operate by using software defined radio technology to reconfigure its broadcasting characteristics as needed.

073. The real issue is how that spectrum is managed, not the lack of available spectrum. A cognitive radio will not only analyse the spectrum usage, but negotiate usage with nearby devices.

Compare the scheme to a driver's reacting to what she sees other drivers doing. If you are in a traffic lane that is heavy, maybe it's time for you to shift to another lane that is not so busy. When shifting lanes, however, a driver needs to follow rules that prevent her from bumping into others.

074. The MAC layer of the IEEE 802.22 wireless standard will be based in Cognitive Radio Technology. It needs to be also able to adapt dynamically to changes in the environment by sensing the spectrum. The MAC layer will consist of two structures: Frame and Superframe. A superframe will be formed by many frames. The superframe will have an SCH (Superframe Control Header) and a preamble. These will be sent by the BS in every channel that it's possible to transmit and not cause interference. When a CPE is turned on, it will sense the spectrum, find out which channels are available and will receive all the needed information to attach to the BS. Two different types of spectrum measurement will be done by the CPE: in-band and out-of-band. The in-band measurement consists in sensing the actual channel that is being used by the BS and CPE. The out-of-band measurement will consist in sensing the rest of the channels. The MAC layer will perform two different types of sensing in either in-band or out-of-band measurements: fast sensing and fine sensing. Fast sensing will consist in sensing at speeds of under 1ms per channel. This sensing is performed by the CPE and the BS and the BS's will gather all the information and will decide if there is something new to be done. The fine sensing takes more time (approximately 25 ms per channel or more) and it is utilized based on the outcome of the previous fast sensing mechanism. These sensing mechanisms are primarily used to identify if there is an incumbent transmitting, and if there is a need to avoid interfering with it.

075. **Importance:** Enables efficient usage of available limited spectrum.

076. **Implications**: Ideal companion technology to Software Defined Radio Technology.

077. **Status**: Approved by IEEE in january of 2008, the 802.22 standard is the first wireless standard based on cognitive radios.

## 2.2.3. Wired Networking

078. When compared to wireless networking, the more mature wired networking area provides benefits in cost, reliabilty and performance.

079. **Implications**: The need for wired networking will be dictated by the operational environment.

### 2.2.3.1. Fibre-Channel over Ethernet (FCoE)

080. Fibre-Channel over ethernet allows Fibre-Channel devices to connect with one another over ethernet based networks. With FCoE, native Fibre-Channel frames are encapsulated into ethernet frames to be sent over a 10-Gbit Ethernet network. Considered a low-cost, high performance alternative to Fibre-Channel over long distances. The main applications that benifet from this technology are sStorage Area Networks (SANs). With FCoE, network (IP) and storage (SAN) data traffic can be consolidated using a single network switch. This consolidation can:

- reduce the number of network interface cards required to connect to disparate storage and IP networks
- reduce the number of cables and switches
- reduce power and cooling costs
- increase utilization of servers through server virtualization technologies

081. **Status**: Not yet apporved as a standard by INCITS, InterNational Committee for Information Technology Standards organisaton, but several vendors are shipping products that will support the future standard. Expected to be ratified in late 2009 or early 2010.

### 2.2.4. Transport Layer

#### 2.2.4.1. Stream Control Transmission Protocol (SCTP)

082. The Stream Control Transmission Protocol operates on top of the Internet Protocol (IP), and is defined in the RFC 2960 (IETF standard). SCTP was developed to provide reliable transport of SS7 messages over an IP network.

083. The Stream Control Transmission Protocol (SCTP) is a new IP transport protocol that operates on top of the Internet Protocol (IP), and is defined in the RFC 2960 (IETF standard). It exists at an equivalent level with UDP (User Datagram Protocol) and TCP (Transmission Control Protocol), which provide transport layer functions to many Internet applications.

084. Like TCP, SCTP provides a reliable transport service, ensuring that data is transported across the network without error and in sequence. Like TCP, SCTP is a session-oriented mechanism, meaning that a relationship is created between the endpoints of an SCTP association prior to data being transmitted, and this relationship is maintained until all data transmission has been successfully completed.

085. Unlike TCP, SCTP provides a number of functions that are critical for telephony signalling transport, and at the same time can potentially benefit other applications needing transport with additional performance and reliability.

086. **Status**: SCTP has been approved by the IETF as a Proposed Standard. The error check algorithm has since been modified. Future changes and updates will be reflected in the IETF RFC index. SCTP has been implemented on several OS: Windows XP, Linux, AIX, BSD, Solaris, and QNX Neutrino.

## 2.3. GREEN INFORMATION TECHNOLOGY

087. There has always been a push to make technology faster. Now, emerging new trends are driving technologies to become more efficient as well. The drivers of these new trends vary from

higher energy costs to environmental concerns. In the past, military interests in technology were less concern with how efficient it was, than how competent it was in producing a desired effect.

088. **Implications**: Reduction of power consumption during mlitary operations directly effects the costs of conducting such operations. From a NATO perspective, cost-savings incurred through efficiency will have larger impact on participants with less finanical resources to devote to NATO operations.

## 2.3.1. IEEE 802.3az (Green Ethernet)

089. The goals of the IEEE 802.3az task force are pretty straightforward: define a mechanism to reduce power consumption during periods of low link utilization and a protocol to coordinate transitions to or from a lower level of power consumption. It'll work only on new hardware, of course, but that hardware should be fully backward-compatible. Using "channel staggering" in combination with a few other technologies may lead to a 50-85% power savings.

090. **Status**: First draft of the specification should by out by the end of 2008, though the final version won't be ratified until early of 2010.

## 2.3.2. IEEE 1680 (Environmental Assessment)

091. Modern IT systems rely upon a complicated mix of people, networks and hardware; as such, a green computing standard must be systemic in nature, and address increasingly sophisticated problems. The IEEE 1680 standard defines 51 criteria used in the assessment of computing products for enironmental imapct. Impact is measure by reduced use of hazardous materials, maximum energy efficiency during a product's lifetime, and promotion of recyclability or biodegradability of defunct products. Products that passes at least 21of the the 51 criteria, are eligble to be certified as Energy-Star or EPEAT compliant.

092. **Status**: Ratified in 2006, the standard was viewed as ambiguous in how to apply specific criteria. Recent verification rounds has prompted detailed clarification and established Interpretations of some portions of the IEEE 1680 standard. With the new supplemental guidance it should be more widely accepted over the next 3-5 years.

# 2.4. CLOUD COMPUTING

093. The "Cloud" in Cloud computing describes a combination of inter-connected networks. This technology area focuses on breaking up a task into sub-tasks. The sub-tasks are then executed simultaneously on two or more computers that are communicating with each other over the “Cloud”. Later, the completed sub-tasks are reassembled to form the completed original main task. There are many different types of distributed computing systems and many issues to overcome in successfully designing one. Many of these issues deal with accommodating a wide-ranging mix of computer platforms with assorted capabilities that could potentially be networked together

094. **Implications**: The main goal of a cloud computing system is to connect users and resources in a transparent, open, and scalable way. Ideally this arrangement is drastically more fault tolerant and more powerful than many combinations of stand-alone computer systems. If practiced in a NATO environment, member nations would consume their IT services in the most cost-effective way, over a broad range of services (for example, computational power, storage and business applications) from the "cloud," rather than from on-premises equipment.

## 2.4.1. Platforms

095. Cloud-computing platforms have given many businesses flexible access to computing resources, ushering in an era in which, among other things, startups can operate with much lower infrastructure costs. Instead of having to buy or rent hardware, users can pay for only the processing power that they actually use and are free to use more or less as their needs change. However, relying on cloud computing comes with drawbacks, including privacy, security, and reliability concerns.

### 2.4.1.1. Amazon's Elastic Compute Cloud (EC2)

096. Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers. If your application needs the processing power of 100 CPUs then you scale up your demand. Conversely, if your application is idle then you scale down then amount of computing resources that you allocate.

097. **Status**:The first company to successfully levearge the excess computing resources from its primary bussiness. Currently, CPU cycles and storage are at pennies per hour or GB.

### 2.4.1.2. Microsoft's Azure Services Platform

098. Windows® Azure is a cloud services operating system that serves as the development, service hosting and service management environment for the Azure Services Platform. Windows Azure provides developers with on-demand compute and storage to host, scale, and manage Web applications on the Internet through Microsoft® data centers.

099. **Status**: During the Community Technology Preview (CTP) developers invited to the program, which includes all attendees of the Microsoft Professional Developers Conference 2008 (PDC), receive free trial access to the Azure Services Platform SDK, a set of cloud-optimized modular components including Windows Azure and .NET Services, as well as the ability to host their finished application or service in Microsoft datacenters.

### 2.4.1.3. Google App Engine

100. Google App Engine enables you to build web applications on the same scalable systems that power Google applications. App Engine applications are easy to build, easy to maintain, and

easy to scale as your traffic and data storage needs grow. With App Engine, there are no servers to maintain: You just upload your application, and it's ready to serve to your users. Google App Engine applications are implemented using the Python programming language.

101. **Status**: Currently in the preview release stage. You can use up to 500MB of persistent storage and enough CPU and bandwidth for about 5 million page views a month for free. Later on if you want additional computing resources, you will have to purchase it.

## 2.4.2. Grid Computing

102. Grid computing is the collective name of technologies that attempt to combine a set of distributed nodes into a common resource pool. The term grid computing stems from an analogy with electric power grids that combine a large set of resources (power plants, transformers, power lines) into simple well defined product (the power outlet) that the user can use without having to know the details of the infrastructure behind it.

103. Typical for grid computing is also that it offers a framework for management of node memberships, access control, and life cycle management. Common applications of grid computing allow well defined organisations to share computational resources or storage resources so that resources may be used efficiently and resource demanding tasks can be performed that would otherwise have required large specialised and/or local investments.

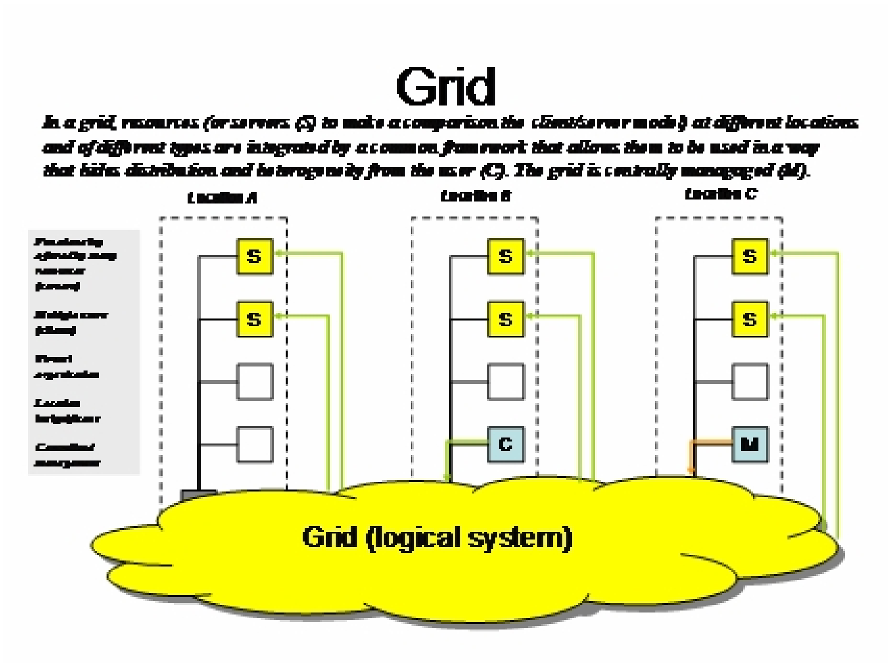


**Figure 2.4. Grid Computing**

104. While some grid computing systems have been designed for a specific purpose, some standards for Grid infrastructure have also evolved that make the task of setting up a Grid easier

and provide a common interface to application developers. Such standardisation efforts have resulted in Globus Toolkit [51] and OGSA (Open Grid Services Architecture) [53].

105. The Global Grid Forum (GGF) [52] is a set of working groups where much work on grid computing standardisation is ongoing, and that also is behind the OGSA standard. Their web site is a good source of information about ongoing work in the field and examples of grid projects.

### 2.4.2.1. Globus Toolkit

106. Globus Toolkit [51] offers tools and APIs for building secure grid infrastructures. It offers a secure infrastructure (GSI) on top of which support for resource management, information services, and data management is provided. It is being developed by Globus Alliance [50], and is among other applications being used as a foundation for implementation of OGSA.

### 2.4.2.2. OGSA

107. OGSA [53] (developed by the Global Grid Forum, GGF [52]) builds on a combination of Globus Toolkit [51] (developed by the Globus Alliance [50]) and Web service technologies to model and encapsulate resources in the Grid. A number of special Web service interfaces are defined by OGSA that support service management, dynamic service creation, message notification, and service registration. A number of implementations of OGSA have been made, including for example OGSI (Open Grid Services Infrastructure) and WSRF (Web Services Resource Framework, developed by OASIS [47]). Today, WSRF is the chosen basis for further development of OGSA

### 2.4.2.3. OSGi

108. OSGi is a standard for a framework for remotely manageable networked devices [25]. Applications can be securely provisioned to a network node running an OSGi framework during runtime and thus provides the possibility to dynamically manage the services and functionality of the network node. The OSGi model is based upon a service component architecture, where all functionality in the node is provided as "small" service components (called bundles). All services are context aware of each other and heavily adapt their functionality depending on what other services are available. Services must degrade gracefully when the services they depend upon are not available in the framework. These network nodes are designed to reliably provide their services 24/7/365. Adding an OSGi Service Platform to a networked node/device adds the capability to manage the life cycle of the software components in the device. Adding new services thus makes it more future proof and gives the node flexibility.

109. OSGi adopts a SOA based approach where all bundles deployed into an OSGi framework are described using well defined service interfaces. The bundle uses the framework's name service for publishing offered services and to retrieve services needed by the bundle itself. OSGi works well together with other standards and initiatives for example Jini or Web Services. OSGi is also an example of a technology where integration is carried out in the Java environment but the actual implementation of the services can be written in other languages, such as C.

## 2.4.3. Decentralised Computing

110. Another trend in distributed system is to decrease the dependence on centralised resources. A centralised resource is typically some service of function implemented by dedicated nodes in the distributed system that many of or all other nodes depend on to perform their own services or functions. Examples of such services are shared databases, network routing and configuration functions, and name or catalogue services. Obviously, this may cause dependability problems as the centralised server becomes a potential single point of failure (). From some points of view, decentralisation (i.e To decrease the dependence single nodes), is therefore a property to strive for. However, decentralisation may also result in a (sometimes perceived) loss of control that fits poorly with traditional ways of thinking of, for example, security. Decentralisation can thus have a rather long-reaching impact on the way distributed systems are designed.

111. Taken to its extreme, decentralisation strives for distributed systems where all nodes are considered equal in all respects (except of course their performance and capacity), i.e., all nodes are considered to peers. This is the foundation to peer-to-peer (P2P) systems, which will be discussed later. In such systems, decentralisation is realised by offering mechanisms to maintain a global shared state that is not stored by any single node.

### 2.4.3.1. Peer-to-Peer (P2P)

112. Peer-to-peer, or P2P for short, is a technology trend that has received much attention in recent years. Unfortunately, much of this attention has been oriented towards questionable applications of P2P, such as illegal file sharing, rather than towards its merits as a technology that addresses important problems with traditional distributed systems.

113. The fundamental idea behind P2P is, as is implied by its name, that all participating nodes in a distributed system shall be treated as peers, or equals. This is a clear deviation from the client/server concept, where some nodes play a central role as servers and other nodes play a role as clients. In those systems, the server nodes become critical for the system function, and thus need to be dependable, highly accessible, and dimensioned to handle a sometimes unpredictable workload. Obviously this may make a server node both a performance bottleneck and a dependability risk. P2P addresses such problems.

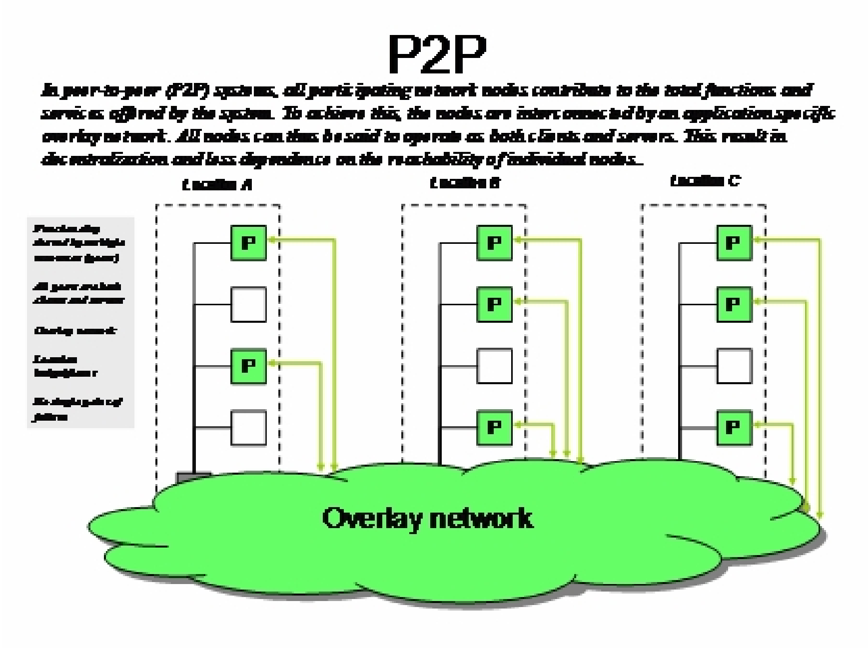


**Figure 2.5. Peer-To-Peer**

114. The fundamental important property of many P2P applications is that they allow storage of named objects, such as files, services, or database entries, to be spread over all nodes in a system instead of having to store and access them on centralised server nodes. Object names can be numbers or character strings; whichever is appropriate for the applications. Once stored in the system, any node can access a named object just by knowing its name. This means that a P2P system can have a global shared state that does not depend on any centralised node.

115. While in principle avoiding a centralised solution, many early P2P systems, such as the Napster file sharing system actually relied on some central functions in order to implement the mapping from object names to object locations. However, in later generations of P2P decentralisation has been taken another step further, by the introduction of overlay networks, earlier in this report mentioned as a form of virtual networks.

116. With an overlay network, a distributed means of finding the node that is responsible for storing an object with a given name is provided. Typically the set of all possible object names, called the name space, is divided into subsets such that each node becomes responsible for one subset of the name space. This means that the need for centralised resources is completely avoided. For a node to become part of a P2P system, i.e. To join the overlay network, all that is needed is knowledge of any other node already part of the system. As nodes join and leave the system, the responsibility for name space subsets is automatically redistributed.

117. The development of overlay network based P2P systems has been driven by a striving to improve scalability, guarantees, and robustness. Today, a logarithmic logical scalability can be achieved, which means that to find a given node from any other node in the system requires at most logk(N) node-to-node messages to be sent, where k is some constant and N is the maxim-

um number of nodes in the system. Note, however, that this scalability measure does not automatically translate into an exact measure of the actual time it takes to send a message between two nodes as this time will depend also on the distribution of nodes on the underlying physical network.

118. The scalability issue has been addressed by a number of proposed P2P implementation techniques developed within academic research projects such as Chord [40], Pastry [41], and Tapestry [42]. However, scalability has been taken yet another step further by the DKS system developed at the Swedish Institute of Computer Science (SICS. In DKS, the amount of administrative traffic required to keep track of nodes in the overlay network is significantly reduced, and dimensioning parameters of the system can be fine-tuned in a very general framework (that actually treats the other mentioned techniques as special cases) so as to improve the practical scalability.

119. Another important aspect of P2P systems is also the guarantees that can be given that any named object stored in the systems also can found. Such guarantees have improved over the P2P technology generations, and 100% guarantees can now be given by the DKS system assuming that there are no errors such as physical communication failures that make nodes unreachable. As intermittent or lasting communication failures must be expected in any practical system, techniques for improving the fault tolerance by means of replication of data have been investigated and are now being included into the general frameworks of P2P technologies.

120. However, practical applications of new P2P technologies like DKS in distributed systems need to be investigated in order to determine how well scalability and robustness functions in practise given the impact of underlying infrastructure and application properties. An example of an ongoing such project investigates the properties of a DKS based implementation of central service in the OpenSIS standard [49].

121. To summarise, P2P technologies have matured into a practical way of organising distributed systems in a decentralised way that is both highly scalable and reliable. Excellent reviews and descriptions of P2P technologies can be found in [16], [19], and [20].

122. **Status**: Currently the advantages of P2P technologies (pooling computing power, pooling bandwidth of the participants, and elimination of the server/client distinction) don't outweigh the disadvantages (legal obstacles, and security vulnerabilities)

## 2.4.4. Service Directory Platform (SDP)

123. Service Delivery Platform (SDP) is an architecture that enables the quick development, deployment and integration (convergence) of broadband, video, wireless and wire-line services can cater to many technologies including VoIP, IPTV, HSD (High Speed Data), Mobile Telephony, Online Gaming, etc.

124. Examples of a converged architecture:

- A user can see incoming phone calls (Wire-line or Wireless), IM buddies (PC) or the location of friends (GPS Enabled Device) on their television screen.

- A user can order VoD (Video on Demand) services from their mobile phone or watch streaming video that they have ordered as a video package for both home and mobile phone.

125. SDPs in the converged services world need to be designed and engineered using information and identity engineering techniques as a core discipline because a is supporting online users their services. A needs to be a real time multi function system that interfaces to the back office systems for billing and to the network infrastructure systems. From an information engineering perspective there could be 20-100 information items associated with a user, their devices and their content and if there are 10 million users on the system, it means that the needs scale up to associate with a billion pieces of information used in random ways. SDPs also need to address the issues of converged services management, account control, self care, and entitlements as well as presence based event type services. Service Delivery Platform, identity engineering and white papers on presence based services can be found at *www.wwite.com.

## 2.4.4.1. Lightweight Directory Access Protocol v.3 (LDAP)

126. The following is a partial list of RFCs specifying LDAPv3 extensions:

| RFC | Description |
|---|---|
| RFC 2247 | Use of DNS domains in distinguished names |
| RFC 2307 | Using LDAP as a Network Information Service |
| RFC 2589 | LDAPv3: Dynamic Directory Services Extensions |
| RFC 2649 | LDAPv3 Operational Signatures |
| RFC 2696 | LDAP Simple Paged Result Control |
| RFC 2798 | inetOrgPerson LDAP Object Class |
| RFC 2849 | The LDAP Data Interchange Format (LDIF) |
| RFC 2891 | Server Side Sorting of Search Results |
| RFC 3045 | Storing Vendor Information in the LDAP root DSE |
| RFC 3062 | LDAP Password Modify Extended Operation |
| RFC 3296 | Named Subordinate References in LDAP Directories |
| RFC 3671 | Collective Attributes in LDAP |
| RFC 3672 | Subentries in LDAP |
| RFC 3673 | LDAPv3: All Operational Attributes |
| RFC 3687 | LDAP Component Matching Rules |
| RFC 3698 | LDAP: Additional Matching Rules |
| RFC 3829 | LDAP Authorisation Identity Controls |
| RFC 3866 | Language Tags and Ranges in LDAP |
| RFC 3909 | LDAP Cancel Operation |

| | |
|---|---|
| RFC 3928 | LDAP Client Update Protocol |
| RFC 4370 | LDAP Proxied Authorisation Control |
| RFC 4373 | LBURP |
| RFC 4403 | LDAP Schema for UDDI |
| RFC 4522 | LDAP: Binary Encoding Option |
| RFC 4523 | LDAP: X.509 Certificate Schema |
| RFC 4524 | LDAP: COSINE Schema (replaces RFC 1274) |
| RFC 4525 | LDAP: Modify-Increment Extension |
| RFC 4526 | LDAP: Absolute True and False Filters |
| RFC 4527 | LDAP: Read Entry Controls |
| RFC 4528 | LDAP: Assertion Control |
| RFC 4529 | LDAP: Requesting Attributes by Object Class |
| RFC 4530 | LDAP: entryUUID |
| RFC 4531 | LDAP Turn Operation |
| RFC 4532 | LDAP Who am I? Operation |
| RFC 4533 | LDAP Content Sync Operation |

**Table 2.5. Summary of LDAP Related RFCs**

#### 2.4.4.2. Composite Adaptive Directory Services

127. Data bases have been with the IT industry for 30 years and traditional directories for the last 20 years and they will be with us in the future. However, with the larger scale, converged services and event driven (presence) systems now being developed world wide (e.g. 3G-IMS), information, identity and presence services engineering and the technologies that support it will require some evolution. This could take the form of CADS (Composite Adaptive Directory Services) and CADS supported Service Delivery Platforms. CADS is an advanced directory service and contains functions for managing identity, presence, content and adaptation algorithms for self tuning and with its unique functions, greatly simplifies and enhances the design of converged services SDPs. See Service Delivery Platform

### 2.4.5. Networked Computing

128. Networked computing is a set of technologies that treats the network as a computing platform, enables machine to machine communication, and offer efficient new ways to help networked computers organise and draw conclusions from online data.

129. **Implications**: Reusable, repurposable, and reconnectable data/services will promote the convergence of Service Oriented Architecture and the Semantic Web.

## 2.4.5.1. Web Services

130. Web Services are software systems that enable machine to machine interaction over a network. The Web Services present themselves as web based Application Programming Interfaces (API) that use XML messages to communicate. No one standard defines Web Services, but is comprised of four core standards:

- **Extensible Markup Language (XML)** - A simple platform independent language used to facilitate communication between different computing systems. (W3C)
- **Service Object Access Protocol (SOAP) 1.2** - A protocol for exchanging XML based messages over networks using HTTP, HTTPS, SMTP, or XAMPP protocols. (W3C)
- **Web Services Description language (WSDL) 2.0** - XML document format that describes interfaces and protocols need to connect to a Web Service. (W3C)
- **Universal Discovery, Description, and Integration (UDDI)** - XML based registry that can be queried by SOAP messages, and return WSDL documents so that Web Services can be found and connected to. (OASIS)

131. There are several efforts to extend the capabilities of Web Services.

- **WS-Security** - Defines how to use XML Encryption and XML Signature in SOAP to secure message exchanges, as an alternative or extension to using HTTPS to secure the channel.
- **WS-Reliability** - An OASIS standard protocol for reliable messaging between two Web services.
- **WS-ReliableMessaging** - A protocol for reliable messaging between two Web services, issued by Microsoft, BEA and IBM it is currently being standardised by the OASIS organisation
- **WS-Addressing** - A way of describing the address of the recipient (and sender) of a message, inside the SOAP message itself.
- **WS-Transaction** - A way of handling transactions.

### 2.4.5.1.1. Web Service Specifications

| Technology | Description |
|---|---|
| WS-BPEL | Process composition |
| WSCI | Process composition |
| WSDM | Management and infrastructure |
| JBI | Process composition |
| SCA | Process composition |

| | |
|---|---|
| Java-EE | Management and infrastructure |
| Java-RMI | Distributed systems |
| .NET | Management and infrastructure |
| Jini | Distributed systems, Service selection, Management and infrastructure |
| Rio | Distributed systems, Service selection, Process composition, Management and infrastructure |

## Table 2.6. Summary of Emerging Web Services Technologies

### 2.4.5.1.1.1. Business Process Execution Language for Web Services (WS-BPEL or BPEL4WS)

132. The Business Process Execution Language (BPEL) originally proposed by Microsoft, and Siebel Systems. It is XML-based and is designed as a layer on top of WSDL that allows a standardised way of describing business process flows in terms of web services. A BPEL process can be used either to describe an executable work flow in a node (orchestration), or to describe the protocol for interaction between participants in a business process (choreography). **Status**: As of January 2007, BPEL4WS is now an OASIS standard also referred to as WS-BPEL version 2.0. [23].

### 2.4.5.1.1.2. Web Service Choreography Interface (WSCI)

133. Other Web service based standards for Web service orchestration and choreography are , developed by Sun, , BEA, and Intalio, and BPML, initiated by Intalio, Sterling Commerce, Sun, and through the non-profit (Business Process Management Initiative) corporation. (Web Services Choreography Interface) extends WSDL (rather than being built on top of WSDL like BPEL) and focuses on the collaborative behaviour of either a service user or a service provider. **Status**: The WSCI specification is one of the primary inputs into the W3C's Web Services Choreography Working Group which published a Candidate Recommendation on WS-DSL version 1.0 on November 2005 to replace WSCI.

### 2.4.5.1.1.3. Web Service Distributed Management (WSDM)

134. Web Services Distributed Management (WSDM) [70] is an OASIS [45] standard that specifies infrastructure support for the integration of web service management aspects across heterogeneous systems. This is done through management specific messaging via web services. It consists of main parts:

- WSDM-MUWS. Deals with Management Using Web Services (MUWS), i.e., the fundamental capabilities required to manage a resource.
- WSDM-MOWS. Deals with Management of Web Services (MOWS), and builds on MUWS to specify how web services (as a kind of resource) are managed.

#### 2.4.5.1.1.4. Java Business Integration (JBI)

135. Java Business Integration (JBI) is a Java Specification Request (JSR 208) [72] that aims to extend Java (including Java EE) with an integration environment for business process specifications like , BPEL4WS and those proposed by the W3C Choreography Working Group [71]. It is an example of a technology that implements Enterprise Service Bus (ESB) concepts.

#### 2.4.5.1.1.5. Java Remote Method Invocation (JRMI)

136. Java Remote Method Invocation (JRMI), is a Java specific standard for access to Java objects across a distributed system [39].

#### 2.4.5.1.1.6. Jini

137. Jini network technology [29] [30] is an open architecture that enables developers to create network-centric services that are highly adaptive to change. An architecture based on the idea of a federation rather than central control, Jini technology can be used to build adaptive networks that are scalable, evolvable and flexible as typically required in dynamic computing environments. Jini technology provides a flexible infrastructure for delivering services in a network and for creating spontaneous interactions between clients that use these services regardless of their hardware or software implementations.

138. The Jini architecture specifies a discovery mechanism used by clients and services to find each other on the network and to work together to get a task accomplished. Service providers supply clients with portable Java technology based objects that implements the service and gives the client access to the service. The actual network interaction used can be of any type such as Java [39], CORBA [38], or [54], because the object encapsulates (hides) the communication so that the client only sees the Java object provided by the service.

139. The Rio Project [31] extends the Jini technology [29] [30] to provide dynamic adaptive network architecture and uses a nomadic SOA approach. In a nomadic SOA services can migrate and self optimise their architectural structure to respond to the changing service environment.

140. A fundamental tenet of distributed systems is they must be crafted with the reality that changes occur on the network. Compute resources have assets diminished or fail and new ones are introduced into the network. Applications executing on compute resources may fail, or suffer performance degradation based on diminishing compute resource capabilities and/or assets. Technology used must provide distributed, self-organizing, network-centric capabilities. Enables a dynamic, distributed architecture capable of adapting to unforeseen changes on the network.

141. **Importance**: This architecture can facilitate the construction of distributed systems in the form of modular co-operating services.

142. **Implications**: Can provide a more stable, fault-tolerant, scalable, dynamic, and flexible solution. Jini also provide the ability to do a better job at upgrading systems, keeping everything running including old clients.

143. **Status**: Originally developed and maintained by Sun Microsystems, but now that responsibility is being transferred to the Apache Software Foundation under the project name of River. There are many initiatives that are based on the Jini technology such as various grid architectures and [31].

### 2.4.5.1.2. Web Services Profiles

144. The Web Services Interoperability organisation (WS-I) is a global industry organisation that promotes consistent and reliable interoperability among Web services across platforms, applications and programming languages. They are providing Profiles (implementation guidelines), Sample Applications (web services demonstrations), and Tools (to monitor Interoperability). The forward looking WS-I is enhancing the current Basic Profile and providing guidance for interoperable asynchronous and reliable messaging. WS-I's profiles will be critical for making Web services interoperability a practical reality.

145. The first charter, a revision to the existing WS-I Basic Profile Working Group charter, resulted in the development of the Basic Profile 1.2 and the future development of the Basic Profile 2.0. The Basic Profile 1.2 will incorporate asynchronous messaging and will also consider SOAP 1.1 with Message Transmission Optimisation Mechanism (MTOM) and XML-binary optimised Packaging (XOP). The Basic Profile 2.0 will build on the Basic Profile 1.2 and will be based on SOAP 1.2 with MTOM and XOP. The second charter establishes a new working group, the Reliable Secure Profile Working Group, which will deliver guidance to Web services architects and developers concerning reliable messaging with security.

146. **Status**: In 2006, work began on Basic Profile 2.0 and the Reliable Secure Profile 1.0. In 2007 the Basic Profile 1.2, the Basic Security Profile 1.0 was approved. More information about WS-I can be found at www.ws-i.org.

### 2.4.5.1.3. Web Service Frameworks

147. A list of Frameworks:

| Name | Platform | Destination | Specification | Protocols |
|---|---|---|---|---|
| Apache Axis | Java/C++ | Client/Server | WS-ReliableMessaging, WS-Coordination, WS-Security, WS-AtomicTransaction, WS-Addressing | SOAP, WSDL |
| JSON RPC Java | Java | Server | - | JSON-RPC |
| Java Web | Java | Client/Server | WS-Addressing, WS-Security | SOAP |

| | | | | |
|---|---|---|---|---|
| Services Development Pack | Java | Client/Server | - | WSDL |
| Web Services Interoperability Technology | Java | Client/Server | WS-Addressing, WS-ReliableMessaging, WS-Coordination, WS-AtomicTransaction, WS-Security, WS-Security Policy, WS-Trust, WS-SecureConversation, WS-Policy, WS-MetadataExchange | SOAP, WSDL, MTOM |
| Web Services Invocation Framework | Java | Client | - | SOAP, WSDL |
| Windows Communication Foundation | .Net | Client/Server | WS-Addressing, WS-ReliableMessaging, WS-Security | SOAP, WSDL |
| XFire | Java | Client/Server | WS-Addressing, WS-Security | SOAP, WSDL |
| XML Interface for Network Services | Java | Server | - | SOAP, WSDL |
| gSOAP | C/C++ | Client/Server | WS-Addressing, WS-Discovery, WS-Enumeration, WS-Security | SOAP, XML-RPC, WSDL |
| NuSOAP | PHP | Server | - | SOAP, WSDL |

## 2.4.5.1.4. Web Services Platforms

### 2.4.5.1.4.1. Java 2 Edition (J2EE)

148. Java Enterprise Edition (formerly known as Java 2 Platform, Enterprise Edition or J2EE up to version 1.4) [35] is a specification of a platform and a code library that is part of the Java

Platform. It is used mainly for developing and running distributed multi-tier Java applications, based largely on modular software components running on a platform (application server). The platform provides the application with support for handling of transactions, security, scalability, concurrency and management of deployed applications. Applications are easily ported between different Java EE application servers. Applications developed for the Java EE can easily support Web Services. Java EE is often compared to Microsoft .Net [36], a comparison that is beyond the scope of this document. But it shall be noted that .Net is a product and framework closely related to development for the Windows operating system whereas Java EE is a specification that is followed by many product vendors.

#### 2.4.5.1.4.2. Microsoft .NET

149. Microsoft .NET framework [36] is a Microsoft product closely related to application development for the Windows platform [36]. The framework includes the closely related C# programming language (even if it is a formal ISO standard) and the Common Language Runtime (CLR), which simplified is Microsoft's response to JAVA. Programs written for the NET. Framework execute in which provides the appearance of an application virtual machine, so that programmers need not consider the capabilities of the specific CPU that will execute the program. The framework also includes libraries for development of web service applications.

## 2.4.5.2. Semantic Web

150. The Semantic Web initiative will make searches more accurate and enable increasingly sophisticated information services like intelligent agents that can find products and services, schedule appointments and make purchases. The initiative includes a sort of grammar and vocabulary that provide information about a document's components; this information will enable Web software to act on the meaning of Web content. Semantic Web software and Web services promise to shift the nature of the Web from a publishing and communications medium to an information management environment.

151. Semantic Web software includes a special set of Extensible Mark-up Language (XML) tags that includes Uniform Resource Identifiers (URL), a Resource Description Framework (RDF), and a Web Ontology Language (OWL).

152. Semantic Web software makes it possible for an intelligent agent to carry out the request "show me the Unmanned Aerial Vehicles (UAV) operating in the current area of responsibility" even if there is no explicit list, because it knows that "area of responsibility" has the property "location" with the value "Kandahar", and in searching a directory of UAVs it knows to skip UAVs belonging to the United States, whose location value is "Kabul", but include German UAVs, whose location value is "Kandahar".

153. Semantic Web software organises Web information so that search engines and intelligent agents can understand properties and relationships. A university, for example, could be defined as an institution of higher education, which is a class of objects that has a set of properties like a population of students.

154. The World Wide Web Consortium released standards in February 2004 that define the two foundation elements of the Semantic Web initiative: the Resource Description Framework (RDF), which provides a structure for interpreting information, and the Web Ontology Language (OWL), which provides a means for defining the properties and relationships of objects in Web information.

155. Web services provide a way for software to communicate with each other over the Web, enabling a form of distributed computing in which simple services can be combined to carry out complicated tasks like financial transactions.

156. Our most fundamental sensors are our senses themselves. They are quite sophisticated, the product of a complex evolutionary design. And yet we've improved on them as time has passed: telescopes and microscopes extend our eyes, thermometers extend our touch, and satellite dishes extend our ears. In addition, virtual sensors have been used for many years to monitor our computing environments. Smaller and more powerful computer processors allow sensors to be small and inexpensive enough that they can be everywhere. And with the advent of trillions and trillions of IPv6 addresses, they can all be networked.

157. Networks, human or technological, are designed to communicate information from one point to others. But the value of a network is entirely dependent on the information it contains. And so the sensors that feed information into a network play a crucial role in maximising a network's value. Simply put, the better the sensors and the better the information they provide, the more valuable the network becomes.

158. Advanced sensors that report directly about their physical environment will enable truly revolutionary applications. Already there are sensors that can detect, measure, and transmit any physical quality such as temperature, pressure, colour, shape, sound, motion, and chemical composition. And, as sensors are becoming more sophisticated, they are also shrinking in size. Some are so tiny that they are difficult to detect.

159. Emerging sensor network technologies will be autonomous, intelligent, and mobile. These sensors will reconfigure themselves to achieve certain tasks. These requirements will provide rigid requirements for the computing, and delivery systems of the future. The networks and computing systems must reorganise themselves to serve the distributed agents with needs to communicate and exchange decisions, actions, and knowledge to other agents in secured environment.

## 2.4.5.3. Service Component Architecture

160. Service component architecture (SCA) [73] is a technology development initiative driven by a group of middle-ware vendors. SCA extends and complements existing standards for service implementation and for web services; the goal is to simplify application development and implementation of SOA.

161. SCA components operate at a business level and are decoupled from the actual implementation technology and infrastructure used. SCA uses Service Data Objects (SDO) [74] to repres-

ent the business data that forms parameters and return value between the services. SCA thus provides uniform Service access and uniform Service data representation.

162. **Status**: The current SCA specifications are published in a draft version (0.9) at the vendor's web sites [73].

## 2.5. SECURITY

163. There is an explosion of protocols and standards dealing with identities. These range from identity, authentication, access control, compliance, workflow, policy, storage, etc. From these protocols and standards we are seeing infrastructure that is being developed to support them. There is a growing trend to provide security infrastructure openly so that there is interoperability and collaboration in the "Security Environment". From this infrastructure many applications will be written, such as signal sigon.

164. **Implication**: For an enterprise, this means a lower cost of password and account management, and lower user frustration by allowing users to control of their login.

### 2.5.1. Authentication

#### 2.5.1.1. OpenID

165. OpenID is a decentralised single sign-on system. Websites using OpenID allow web users to abandon the need to remember traditional authentication tokens such as user name and password. Instead, they only need to be previously registered on a website with an OpenID "identity provider", sometimes called an i-broker. Since OpenID is decentralised, any website can employ OpenID software as a way for users to sign in; OpenID solves the problem without relying on any centralised website to confirm digital identity.

166. **Status**: OpenID is increasingly gaining adoption among large sites, with organisations like AOL acting as a provider. In addition, integrated OpenID support has been made a high priority in Firefox 3 and Microsoft is working on implementing OpenID 2.0 in Windows Vista. A non-profit organisation,OpenID Europe, was created in 2007 to support and promote the OpenID framework in Europe.

#### 2.5.1.2. Bandit Project

167. The Bandit project is a worldwide open source community that enables open yet secure enterprise computing through an Open Identity System. Bandit's components will create an environment where, the right people get the right access to the right IT systems at the right time. The Bandit project is sponsored by Novell, which contributes significant engineering, management and infrastructure resources. Novell, in consultation with the Bandit community, sets the project engineering goals and retains ultimate responsibility for the project.

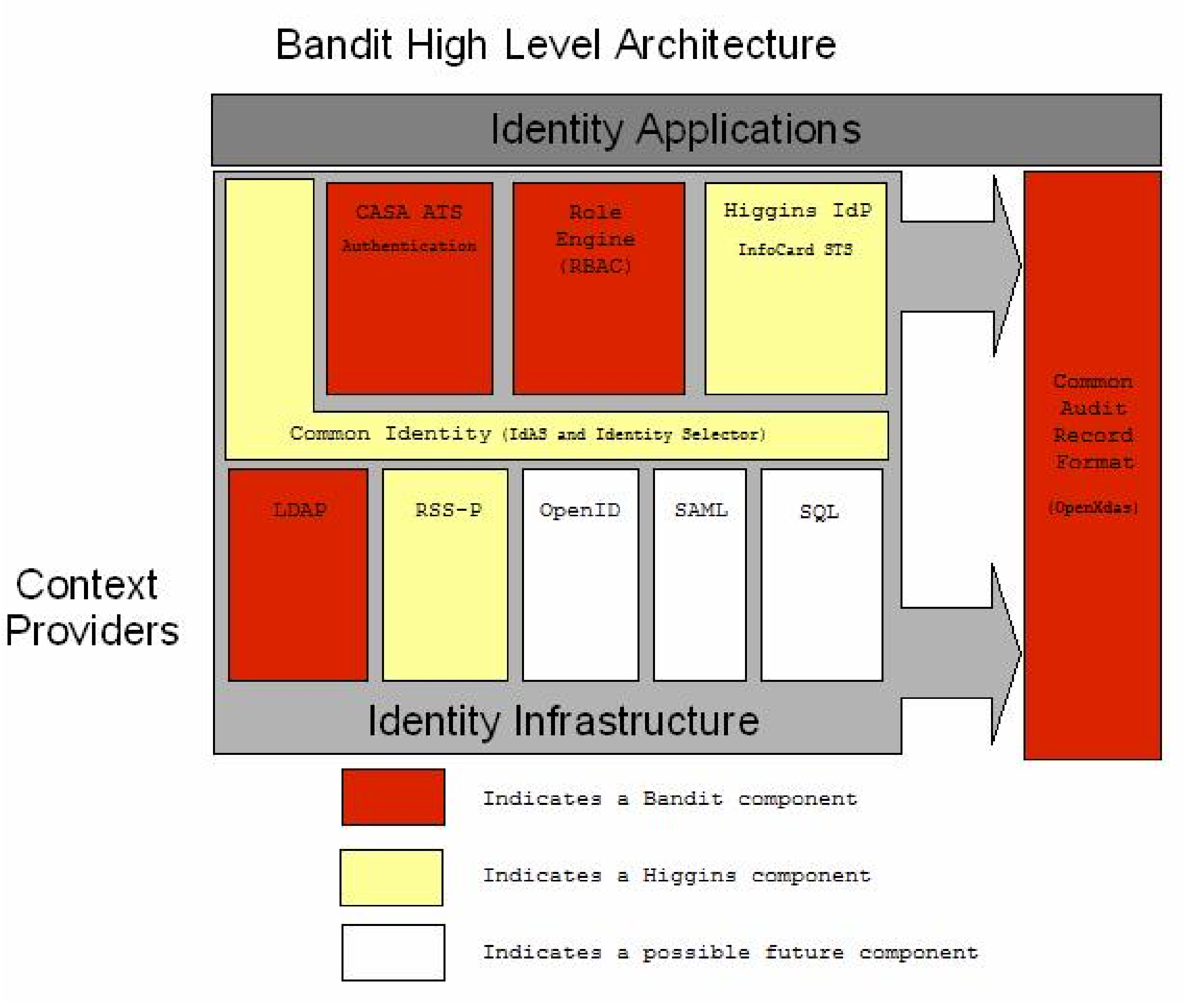


**Figure 2.6. Bandit High Level Architecture**

168. Bandit's current emphasis is in the following areas:

- Provide simple application access to multiple identity stores
- Support multiple and pluggable authentication methods to provide consistent application access
- Provide a simple application interface to unify system access based on roles
- Allow applications to easily participate in a common compliance system

169. **Status**:Work is being done on version 2 of the Common Identity component and the Role Engine component.

## 2.5.2. Risk Analytical Engines

170. Risk Analytical Engines are used predict risk based on models. Risk assessments are done real-time.

171. **implications**: Risk Analytical Engines are used in a variety of industries such as financial, health, and customer service. But it is the potential use in enterprise identity management and network intrusion detection that makes it an attractive technology category.

### 2.5.2.1. Predictive Model Markup Language (PMML)

172. Predictive Model Markup Language (PMML) describes predictive analytical models that are conventionally used to analyse data in a data warehouse. PMML provides a method for systems, or computer programs to access an analytical model by providing a web services abstraction of the analytical model. This allows the invocation of the analytical model hosted by an analytic engine through a web services interface to the analytic engine. Invocation of the analytical model through the web services interface may be independent of the analytic engine hosting the analytical model.

# 3. STANDARDS

## 3.1. INTRODUCTION

173. This purpose of this chapter is to specify the NISP mid term emerging standards. The document organises these standards into five service areas. These service areas are listed in volume 2.

174. This section presents all associated standards and profiles in tabular form. The tables refine each service area into one or more service categories, with service components mapping to the emerging mid term category (see NISP vol. 1). A remarks column provides optional supplementary information on each standard plus CCEB-specific information. The NISP Rationale Document (RD) provides further explanation on why service and standards categories have been selected.

## 3.2. OPERATIONAL MISSION/ACTIVITIES/TASKS

175. This service area is detailed in the corresponding section of volume 2.

### 3.2.1. List of Standards

| SUBAREA / SERVICE CATEGORY | CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|---|
| | | | |

## 3.3. USER INFORMATION SERVICES

176. This service area is detailed in in the corresponding section of volume 2.

### 3.3.1. List of Standards

| SUBAREA / SERVICE CATEGORY | CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|---|
| | | | |

## 3.4. TECHNICAL SERVICES

177. This service area is detailed in in the corresponding section of volume 2.

## 3.4.1. List of COI Standards

| **SERVICECATEGORY / CATEGORY / SUBCATEGORY** | **EMERGING MID TERM** | **Remarks** |
|---|---|---|
| **Generic COI Services** | | |
| Meteo | | |
| Map View | | |
| Map Mgmt | | |
| Spatial Geography Visualisation | | |
| **Specific COI Services** | | |
| Communicate and Inform | | |
| *Battlespace Mgmt* | | |
| *Orbat Mgmt* | | |
| *Overlay Mgmt* | | |
| *Symbol Mgmt* | | |
| *Tracking* | | |
| *Synchronisation* | | |
| *Distribution* | | |
| *Notification* | | |
| *Aggregation* | | |
| Collaborate and Plan | | |
| *Plan Workspace* | | |
| *Plan Analysis* | | |
| *Plan Briefing* | | |
| *Plan Replay* | | |
| *Plan Synchronisation* | | |
| *Plan Collaboration* | | |
| *Simulation* | | |
| *Collaboration analysis* | | |
| Sense and Respond | | |

| SERVICECATEGORY / CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|
| *Tasking* | | |
| *Plan Deviation Monitor* | | |
| JCOP | | |
| Logistics Svcs | | |
| *Supply Chain Svcs* | | |

## 3.4.2. List of Information Integration Standards

| SERVICECATEGORY / CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|
| **Core Enterprise Services** | | |
| Discovery | | |
| *Service Discovery Services* | | |
| | ebRIM v3.0, OASIS | ebXML Registry Information Model |
| *Information Discovery Services* | | |
| | OWL-S | |
| Repository | | |
| *Metadata Registry Services* | | |
| *Enterprise Directory Services* | | |
| Mediation | | |
| *Composition Services* | | |
| *Translation Services* | | |
| Interaction | | |
| *Messaging Services* | | |
| *Publish/Subscribe Services* | | |

| SERVICECATEGORY / CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|
| *Transaction Services* | | |
| *Collaboration Services* | | |
| Infrastructure | | |
| *Application Services* | | |
| | Office Open XML, ISO/IEC 29500:2008 | XML variant of Microsoft Office. |
| *Storage Services* | | |
| *Web Services* | | |
| *Device Independent Console* | | |
| *Content Mgmt* | | |

## 3.4.3. List of Communications Standards

| SERVICECATEGORY / CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|
| **Network and Transport Services** | | |
| Mixed DISA standards | | |
| | ZigBee 1.0 | |
| | WiBree | |
| | W-USB | |
| | 6LoWPAN | |
| | 5G | |
| | Mobile WiMax | |
| | Mobile-Fi | |
| | WiBro | |
| | HIPERMAN | |
| | Flash-OFDM | |
| | UWB | |

| SERVICECATEGORY / CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|
| | OGSA | |
| | OSGi | |
| | SCTP | |
| **Data Link and Connection Service** | | |
| External Networks | | |
| Tactical Area Comms | | |
| Transmission | | |
| VLF | | |
| HF | | |
| VHF | | |
| UHF | | |
| UHF SATCOM | | |
| SHF SATCOM | | |
| EHF SATCOM | | |
| QoS | | |

## 3.5. INFORMATION ASSURANCE

### 3.5.1. List of Standards

| SUBAREA / SERVICE CATEGORY | CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|---|
| SMI Service | | | |
| Confidentiality | | | |
| Encryption | | | |
| Integrity | | | |
| Authentication | | | |
| Detection | | | |
| Transsec | | | |

## 3.6. SERVICE MANAGEMENT AND CONTROL

| SUBAREA / SERVICE CATEGORY | CATEGORY / SUBCATEGORY | EMERGING MID TERM | Remarks |
|---|---|---|---|
| Mgmt Info Publisher | | | |
| Mgmt Info Subscriber | | | |
| Mgmt Info Collector | | | |
| Mgmt Info Provider | | | |
| Asset Mgmt | | | |
| User Mgmt | | | |
| System Mgmt | | | |

# A. ACRONYMS

| Standards organisations | |
|---|---|
| IETF | Internet Engineering Task Force |
| IEEE | International Electronics and Electrical Engineering Society |
| INCITS | International Committee for Internet Technology Standards |
| IEC | International Electrotechnical Commission |
| ISO | International Standards organisation |
| ITU | International Telecomunications Union |
| OASIS | organisation for the Advancement of Structured Information Standards |
| OMG | Object Management Group |
| TTA | |
| W3C | World Wide Web Consortium |
| WS-I | Web Services Interoperability Organisation |

**Table A.1. Standards organisations**

| Terms | |
|---|---|
| 1xRTT | 2.5G CDMA data service up to 384 kbps |
| AMPS | Advanced mobile phone service |
| CDMA | Code division multiple access |
| DISA | Defense Information Systems Agency [US] |
| ebXML | Electronic Bussiness Extensible Modelling Langauge |
| EDGE | Enhanced data for global evolution |
| FDMA | Frequency division multiple access |
| GPRS | General packet radio system |
| GSM | Global system for mobile |
| IEG | Information Exchange Gateway |
| NATO | North Atlantic Treaty organisation |
| NCOW | Net Centric Operations and Warfare |
| NGO | Non-Government organisation |
| NMT | Nordic mobile telephone |
| NNEC | NATO Network Enabled Capability |
| NRF | NATO Reaction Force |
| PDC | Personal digital cellular |

| | |
|---|---|
| PSTN | Pubic switched telephone network |
| RHQ AFNORTH | Regional Headquarters Allied Forces North Europe |
| SHAPE | Supreme Headquarters Allied Powers Europe |
| SOA | Service Oriented Architecture |
| TACS | Total access communications system |
| TDMA | Time division multiple access |
| UDDI | Universal Description and Discovery Interface |
| WCDMA | Wideband CDMA |
| XML | Extensible Modelling Langauge |

**Table A.2. Terms**

# References

[1] *2020 Vision: Business Transformation Through Technology Innovation*. Copyright © 2006. 0929306392. Silicone Press.

[2] *Challenges of Information Technology Management in the 21st Century: 2000 Information Resources Management Association International Conference*. Copyright © 2000. 1878289845. Idea Group Publishing.

[3] *Reference Model for Service Oriented Architectures*. Working Draft 11, OASIS Open, 15 December 2005. Rebekah. Copyright © 2005 OASIS. OASIS.

[4] *Service Oriented Architecture White Paper*. Copyright © 2005 Adobe Systems Incorporated. Adobe Systems Incorporated.

[5] *Service-Oriented Architecture Compass: Business Value, Planning and Roadmap*. Bieberstein, Sanjay Bose, Fiammante, Jones, and Rawn Shah. Copyright © 2006. 0-13-187002-5.

[6] *SOA Service Oriented Architecture Best Practices*. Dirk Krafzig, Karl Banke, and Dirk Slama. Copyright © 2004 Prentice Hall. 0-13-146575-9. Prentice Hall.

[7] *Multi-lateral Interoperability Programme Working Group,, Version 2.2, 27 September 2003*. Copyright © 2003.

[8] *TACOMS Post 2000, Final Study Report, WP13202, Technology Independent Network Architecture Concept Study, TACOMS/WP13202/RD/TACONE/813*.

[9] *NATO RESPONSE FORCE - NATO's Expeditionary Capability, Background Briefing*. Copyright © 2002. Colorado Springs Defense Ministers Meeting.

[10] *NATO Network Enabled Capabilities Feasibility Study, Version 1.0, 30 June 2005.*. Copyright © 2005 NATO C3 Agency. NATO C3 Agency.

[11] *DoD Architecture Framework Working Group, DoD Architecture Framework Deskbook, Version 1.0, 9 February 2004*. Copyright © 2004.

[12] *Defense, C4ISR Framework Compliant Information, Technology Architectures, White Paper*. Jeffery Coffin. Copyright © 2001.

[13] *Using Architectures for Interoperability Assessments, Briefing*. Office of Assistant Secretary of the Navy.

[14] *Systems Architecture Framework (NAF), 7 October 2003*. Copyright © 2003. NATO C3 Agency.

[15] *WiBree Standard To Challenge Bluetooth*. http://www.extremetech.com/article2/0,1558,2023640,00.asp?kc=ETRSS02129TX1K0000532. Rueters and eWEEk.

[16] *Internet distributed computing, web services, peer-to-peer, grid computing, ad hoc networks*. IEEE Computer, Vol 36, Number 5, May 2003. Copyright © 2003. IEEE Computer Society Publications.

[17] *Web Services, Business Process Modelling.*. IEEE Computer,Vol 36 number 10, October 2003. Copyright © 2003. IEEE Computer Society Publications.

[18] *Virtualization and Grid Computing.*. IEEE Computer, Vol 38 number 4, April 2005. Copyright © 2005. IEEE Computer Society Publications.

[19] *Theme Issue On Peer-to-Peer Computing*. Communications of the ACM, Vol 46 number 2, February 2003. Copyright © 2003. ACM Publications Office.

[20] *Discusses Peer-to-Peer Computing*. Communications of the ACM, Vol 46 number 9, September 2003. Copyright © 2003. ACM Publications Office.

[21] *An introduction to virtualisation, http://www.kernelthread.com/publications/virtualization*.

[22] *Business process modelling initiative, now merged with business processing management initiative. http://www.bpmi.org.*.

[23] *OASIS BPEL working group, http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel*.

[24] *ebXML, http://www.ebxml.org*.

[25] *The OSGi Standard Forum*. http://www.osgi.org.

[26] *Ad Hoc Networks: New Life For An Old Concept*. http://www.eurescom.de/message/messageMar2005/Ad_hoc_networks_New_life_for_an_old_concept.asp. Copyright © 2005.

[27] *OWL Web Ontology Language Overview.*. http://www.w3.org/TR/owl-features. W3C.

[28] *Semantic Web Overview*. http://www.w3.org/2001/sw/Activity. W3C.

[29] *Sun's Jini Description*. http://java.sun.com/developer/products/jini/index.jsp. Sun Microsystems.

[30] *Jini Community resource*. http://www.jini.org/. Apache Projects.

[31] *Jini Project*. http://rio.jini.org/.

[32] *WSMO Working Group Homepage*. http://www.wsmo.org/.

[33] *Towards Intelligent Web Services: Web Service Modelling Ontology (WSMO)*. Conference Paper on WSMO, Proceedings of the Conference on Intelligent Computing (ICIC),August 23-26, 2005. Feier and Dieter Fensel. Copyright © 2005.

[34] *Web Services Homepage (DAML-S, OWL-S)*. http://www.daml.org/services/owl-s/. Defense Advance Research Projects Agency (DARPA).

[35] *Java EE*. http://java.sun.com/javaee/index.jsp. Sun Microsystems.

[36] *Microsoft .NET Developer Homepage*. http://msdn.microsoft.com/netframework/. Microsoft Inc..

[37] *SDL Forum*. http://www.sdl-forum.org/. SDL Forum Society.

[38] *Homepage (CORBA, IDL)*. http://www.omg.org/. The Object Management Group (OMG).

[39] *Java*. http://java.sun.com/products/jdk/rmi. Sun Microsystems.

[40] *Chord*. http://pdos.csail.mit.edu/chord. MIT.

[41] *Pastry*. http://research.microsoft.com/~antr/pastry. Microsoft Inc..

[42] *Tapestry*. http://oceanstore.cs.berkeley.edu/tapestry.

[43] *DKS*. http://dks.sics.se.

[44] *Grid Enabled Scalable Self-Organizing Services (GES3): A Vinnova-funded project between SICS and KTH*. http://www.sics.se/dsl/ges3. Sweedish Royal Institute of Technonlogy.

[45] *OASIS, http://www.oasis-open.org*. organisation for the Advancement of Structured Information Standards (OASIS).

[46] *Reference Rodel for Service Oriented Architecture SOA-RM, Comittee draft 1.0, 7 February 2006*. http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=soa-rm. Copyright © 2006. organisation for the Advancement of Structured Information Standards (OASIS).

[47] *OASIS WSRF technical committee*. http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsrf. organisation for the Advancement of Structured Information Standards (OASIS).

[48] *FMA Technology Support Study, June 2005*. Copyright © 2005. The Swedish Defence Material Administration(FMV).

[49] *OpenSIS*. http://www.opensis.org.

[50] *Globus Alliance*. http://www.globus.org.

[51] *Globus Toolkit*. http://www.globus.org/toolkit.

[52] *Global Grid Forum*. http://www.ggf.org.

[53] *OGSA*. http://forge.gridforum.org/projects/ogsa-wg.

[54] *SOAP Version 1.2 Part 0: Primer*. http://www.w3.org/TR/2003/REC-soap12-part0-20030624/.

[55] *Component Object Model Technologies*. http://www.microsoft.com/com/default.mspx. Microsoft.

[56] *Web Services Description Working Group*. http://www.w3.org/2002/ws/desc/.

[57] *Web Services Description Language 1.1*. http://www.w3.org/TR/wsdl.

[58] *UDDI*. http://www.uddi.org/.

[59] *RDF*. http://www.w3.org/RDF/.

[60] *RSS 0.9*. http://www.tragicdoughnuts.com/rss/0.9.html.

[61] *RSS 0.91*. http://my.netscape.com/publish/formats/rss-spec-0.91.html.

[62] *RSS 1.0*. http://web.resource.org/rss/1.0/.

[63] *RSS 1.1*. http://inamidst.com/rss1.1/.

[64] *RSS 2.0*. http://inamidst.com/rss1.1/.

[65] *Atom, RFC 4287*. http://tools.ietf.org/html/4287.

[66] *DAML+*. http://www.daml.org/2001/03/daml+oil-index.

[67] *WSMF*. http://www.wsmo.org/papers/publications/wsmf.paper.pdf.

[68] *WSMX Working group*. http://www.wsmo.org/wsmx/index.html.

[69] *WSML Working group*. http://www.wsmo.org/wsml/.

[70] *OASIS WSDM technical committee*. http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsdm.

[71] *W3C Choreography Working Group*. http://www.w3.org/2002/ws/chor.

[72] *Java Specification Request (JSR 208)*. http://www.jcp.org/en/jsr/detail?id=208.

[73] *Service Component Architecture (SCA)*. http://www-128.ibm.com/developerworks/library/specification/ws-sca/.

[74] *Service Data Objects (SDO)*. http://dev2dev.bea.com/pub/a/2005/11/sdo.html.

[75] *Evolution of a Software-Defined Radio Receiver's RF Front-End, RF IC Symp., paper RMO1A-5, June 2006.*. Copyright © 2006.

[76] *The Software Radio Architecture, Mag., vol. 33, no. 5, May 1995, pp. 2638.*. 26-38.

[77] *Beyond Technical Interoperability; Introducing a Reference Model for Measures of Merit for Coalition Interoperability, June 17-19, 2003*. Tolk Andreas. Copyright © 2003 Command and Control Research Program (CCRP). 8th International Command and Control Research and Technology Symposium (ICCRTS).

[78] *The Global Technology Revolution 2020, In-Depth Analyses*. Richard Silberglitt, Philip S. AntÃ³n, David R. Howell, Anny Wong. Copyright © 2006 RAND Corporation. 0-8330-3975-X. RAND Corporation.

This page is intentionally left blank