Maximizing Oil & Gas Asset Performance Using a Distributed Knowledge Network

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Recursion Software, Inc.
October 2006
Also published in the January 2007 issue of Upstream Technologies Magazine

RECURSION SOFTWARE, Inc.

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Introduction

The global petroleum industry is tasked with fueling an increasingly thirsty need for hydrocarbon products. Moreover, the industry is faced with unique challenges ranging from politically unstable regions to the hurricane infested waters of the Gulf of Mexico. In addition to business constraints and drivers at work in other sectors, petroleum producers must also consider environmental concerns and domestic political pressures. Finally, commonly known as the "big crew change," an aging Western workforce will retire over the next few years and with fewer replacements, economies of scale must be found elsewhere.

The exploration & production (E&P) or upstream sector has long been information intensive. Indeed one of today's major service companies was built on data acquisition and information processing. Sometimes referred to as the *digital oilfield*, the drive to automate remote oil and gas operations, including drilling, production, transport, and project management have evolved into a fundamental business process.

Fundamental to the 21st century energy firm, all major operators and principal energy services firms have embraced this data and information intensive business model. Additionally, there is recognition that the experience and learning of other industries can add immediate and sustainable value in this industry.[i]

Other sectors have similar business and technological processes to those routinely used in the E&P segment. Distributed knowledge networks have been successfully deployed providing quality real-time data and information sent from the distributed field and even mobile assets to information hubs or control centers. The upstream segment routinely adopts and adapts technology and processes from others. Digital oilfield management techniques are no different.

Maximizing the performance of digital oilfields requires the use of an intelligent agent software solution embedded into a mobile wireless communications network that enables a distributed knowledge network. The subsequent "intelligent" prioritization system transforms the assessment and decision-making from oil and gas field data gathered remotely from a widely distributed systems and heterogeneous sensor environment.

Recursion Software's *Voyager Edge* software is a powerful next-generation intelligent distributed computing platform for creating and extending applications to geographically distributed knowledge networks.

Digital Oilfield Economics

The economics of the digital oilfield are becoming better understood. In addition to cost savings through "demaning" of offshore facilities, the industry is beginning to understand that the current *state-of-the-art- digital-oilfield* has set the stage for true *lean* energy management.

Lean management is a data and communication intensive view into real time provisioned for immediate control that optimizes process performance. Numerous industries have realized significant economic value utilizing lean techniques and using the right tools and techniques, this sector can reap these benefits as well.[ii]

One study suggests that BP is actually an information company as opposed to a petroleum company since it consumes 19.6 times more resources to manage information than it does operations.[iii] *The Digital Oilfield of the Future* reported that not only could an additional 125 billion barrels be added to petroleum reserves, but that large facility cost reductions could be realized towards the end of the decade as unmanned and sub sea facilities become the norm.[iv] Additional research has confirmed these findings, supporting *time-to-first-oil*, or production start-up, could be reduced up to 50 percent.[v]

Value of Real Time Decision-Making

Oil and gas asset managers are charged to maximize the performance of revenue producing properties while assuring that the field is drained in a manner consistent with the long-term health of the asset. There are three basic limitations managers face during the *life-of-the-field*:

- **Reservoir Constraints**, or the ability to extract oil and gas,
- **Market Constraints**, generally the product price point, and
- **Infrastructure Constraints**, the ability to extract, transport, process, and move to market

As production declines, there are a number of engineering and geo-scientific actions that can be employed to enhance or extend the field's life. Increasingly, firms are taking a systemic approach to this problem employing optimization techniques routinely used in other segments of the process industry. Constraint based modeling is the technique that will realize the economic promise of the digital oilfield.[vi]

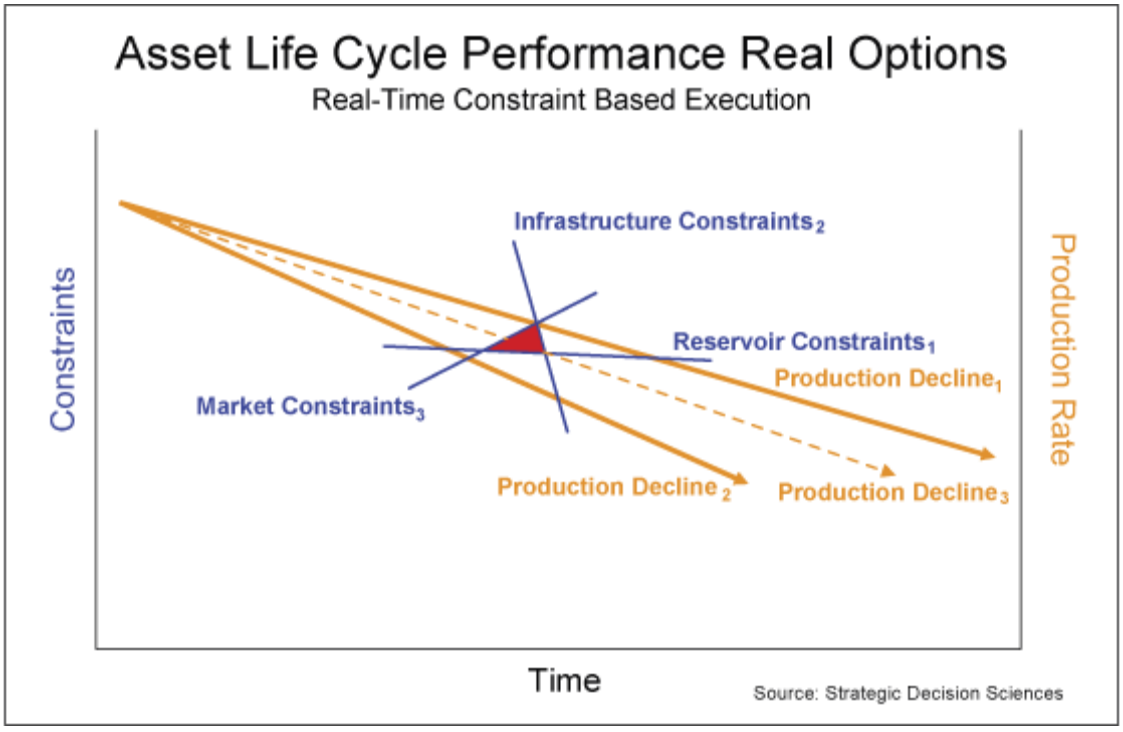

Figure 1

Process optimization requires a consistent stream of process time relevant data and information since actual performance is managed against a theoretical optimum level of performance. Numerous small decisions or tweaking is done 24/7.

Life-of-Field

Essentially a mineral extraction process, every oil and gas field has a finite amount of petroleum. As the asset is *drawn down*, the production characteristics change. For example, as the field enters into its secondary and tertiary recovery phases, certain production enhancement techniques such as water-flooding must be used to stimulate production. Clearly, these additional processes increase the cost while the market dictates product price.

It is imperative that operational costs continue to be driven down faster than the production decline curve if a profitable scenario is to be maintained. Adaptive information systems are a proven method for driving operational costs lower.

The Role of Independent Network Agents

To continue the BP analogy, BP indicated that the company expects to acquire data from its oil and gas wells as well as plants on a global basis and feed it into information hubs so that the expertise of broad based asset teams can be brought to bear on problems and issues wherever these experts reside.[vii]

Most of the major manufacturing sectors seek to maximize profits using adaptive information systems that are driven by updated data and information in process relevant time—a high *velocity of information* scenario. In other words responding to demand driven factors rather than production criteria leads to poor assessment.[viii] The result is a huge amount of network traffic, particularly sensor data from the factory floor.

Software based on intelligent mobile agents contains knowledge that self-configures and addresses velocity of information issues. The integration of Intelligent Mobile Agents (IMA) with the communications protocols of Mobile Ad hoc Network (MANET), wireless mesh network architecture, and sensors will provide a revolutionary approach to access knowledge and implement robust real time decision-making. By localizing intelligent real-time agent decision-making, as well as providing resilient and secure communications network solutions, these agents are able to respond immediately to changing states reducing the need for centralized management systems to scan or poll sensors. This can be achieved by integrating the Ultra Wideband (UWB) technology with communications links and IMA. UWB provides high data rate, secure, multi-path immune, and reliable communication in a cluttered environment.

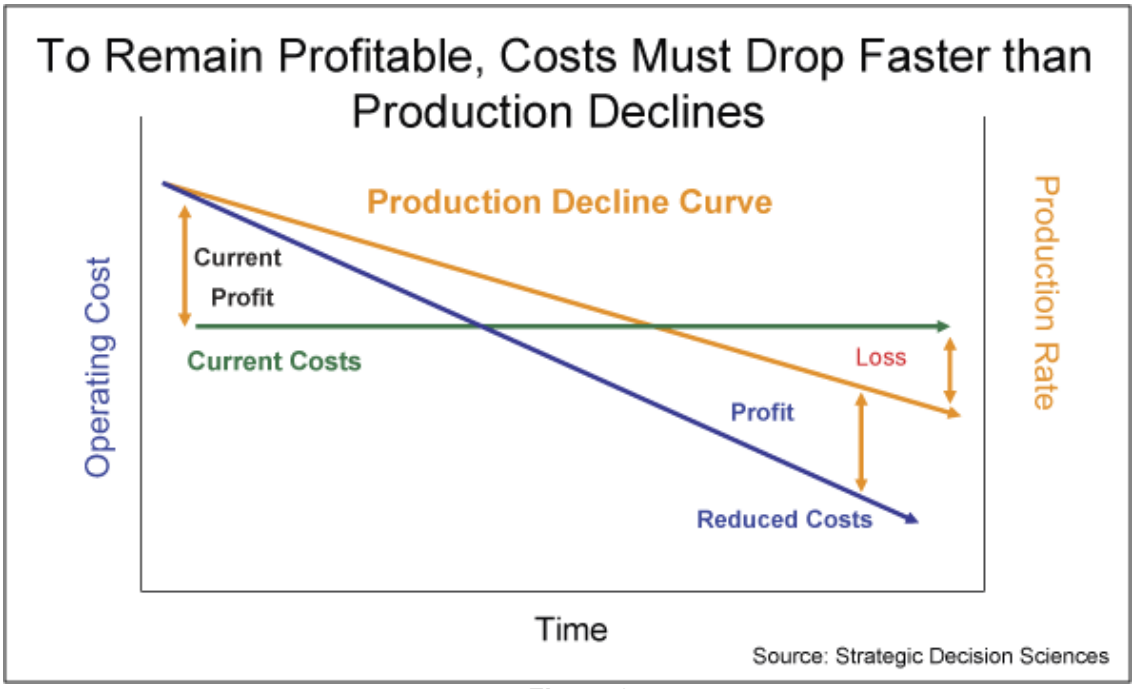

Figure 2

Remote operations, particularly deepwater drilling and production rely on wireless communications. In some cases not all the data is transmitted back to the Real Time Operations Centers (RTO) but is held on local servers. This data reduction degrades the ability of operators to make decisions and places severe restrictions on digital oilfield initiatives. The use of independent knowledge agents augments this process high-grading the overall decision support solution and enabling the digital oilfield.

Thought Leadership from Other Sectors

Recursion Software is currently participating government programs in conjunction with the Department of Defense. A Distributed Cooperative Human Agent Problem Solving Network is in the development stage using Recursion's intelligent mobile agent technology as a platform for a distributed system working cooperatively to perform joint after action review of training exercises.

The program, called the United States Joint Forces Command's, Joint After Action Review Toolset, involves dispatching intelligent, mobile agents to gather, filter and analyze data from a wide range of external devices and data sources. Actionable knowledge from the data is then quickly disseminated to observers/controllers on a wide range of devices including PDAs, Smartphones, Tablets, Laptops and PC's over heterogeneous wired and wireless networks.

Recursion is also working with Virginia Tech University to provide distributed knowledge networks on ultra wide-band wireless networks, providing a powerful combination of decentralized, intelligent, mobile agents running over an *ad-hoc*, *peer-to-peer* wireless network. This powerful combination of technologies is under consideration for use in several high-profile government programs related to disaster recovery and terrorist response.

Additionally Recursion Software is currently developing a widely distributed knowledge-sharing application for a major health care software product company, also using intelligent mobile agent technology. Specifically this involves coordinating, updating and distributing outpatient billing information between the treating hospital administration staff, treating doctor and medical coders regardless of where they are, how many devices they use, and what the device types are (i.e., desktop, laptop, PDA, Smartphone).

The application architecture is constructed in such a way to guarantee that the domain experts and participants in the network receive the information on every device accessible to them. Sensitive data transmitted to, and persisted on edge devices and the enterprise is encrypted per HIPAA standards. Just as importantly, once the participant has completed their initial review of the information and responded using a given device, the information is removed from the participant's other devices, avoiding redundant/superfluous effort.

The underlying architecture and intelligent mobile agent technology can be fully utilized for many scenarios, including billing and treatment. The only variant is the type of information being passed and analyzed.

Recursion's Solution to the Digital Oilfield

The foremost challenge to developing a business and technical model for maximizing oil and gas asset performance is the integration, fusion and analysis of various homogeneous and heterogeneous sensor data into the near real-time assembly and dissemination. The dissemination of intelligence occurs across a distributed network to the oil and gas management and supply chain partners.

The implementation of this type of system requires the deployment of a large-scale, intelligent, autonomous, and self-configuring network with associated computer applications. The system framework must allow ease of integration, ease of future growth, and meet the evolving needs of digital oil field operations and process manufacturing sectors.

Intelligent mobile software agents, a key technology prevalent today in sensor networks and network and system management, are a vital component of the infrastructure of RTO incorporating PDAs, Smart-phones, local servers, laptops/desktops and sensor arrays. These agents can detect a change in state at the device level, prioritize and intelligently integrate sensor data from all available sources and translates data into actionable knowledge to autonomously detect, track, and warn of changing conditions in the field. Agent intelligence automation allows operators to respond to in near real-time.

These agents decentralize decision-making and give more autonomy at the device level to:

- Reduce network traffic, enable self-configuration, and make the overall system more resilient to failure and delay,

- Detect changes in state at the device and respond immediately,
- Filter, analyze and prioritize sensor data into resulting actionable knowledge, and
- Enable the intelligent integration of knowledge from all available sources.

The implementation of this concept will utilize the integration of several communications technologies: mesh network architecture, Mobile Ad Hoc Network (MANET), Software Defined Radio (SDR), UWB and IMA. The result is a *knowledge-driven* oil and gas production *digital network* that transforms raw data at the source (i.e. sensor) into actionable intelligence for immediate and highly effective response by operators and managers of the oil and gas fields and facilities.

Recursion software provides the software development environment, tools, foundation structure and domain expertise upon which to develop the Distributed Knowledge Network required to localize intelligence, reduce network traffic, enable self-configuration, and makes the overall system more resilient to failure and delay.

A high-level architecture depiction (Figure 3) is provided below that shows the interaction of the Agents on edge devices and their relationship to the Agent Coordinators/Managers responsible for managing their location, lifecycle, and performance and the Real Time Operation or Control Room. The high level architecture is supported by a wireless mesh mobile ad hoc network (Figure 4) using UWB software defined radios.

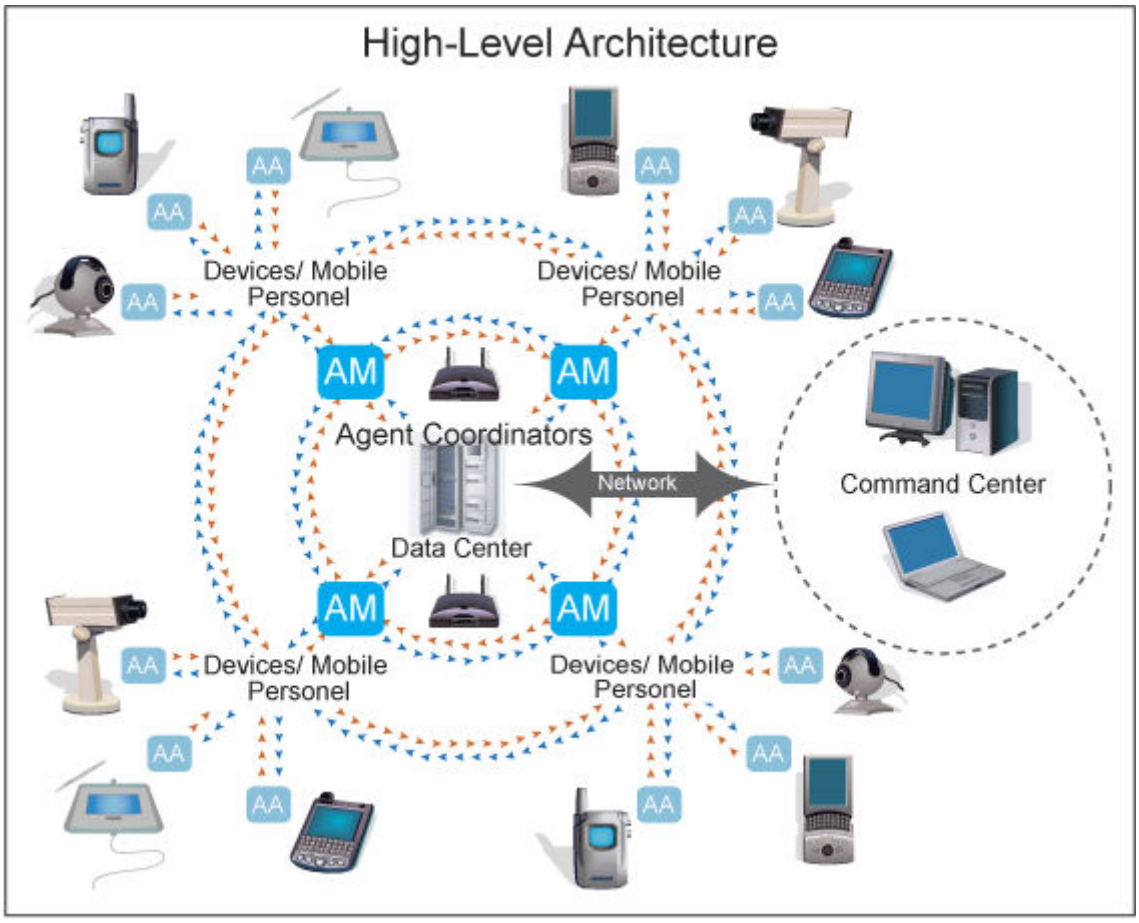

Figure 3

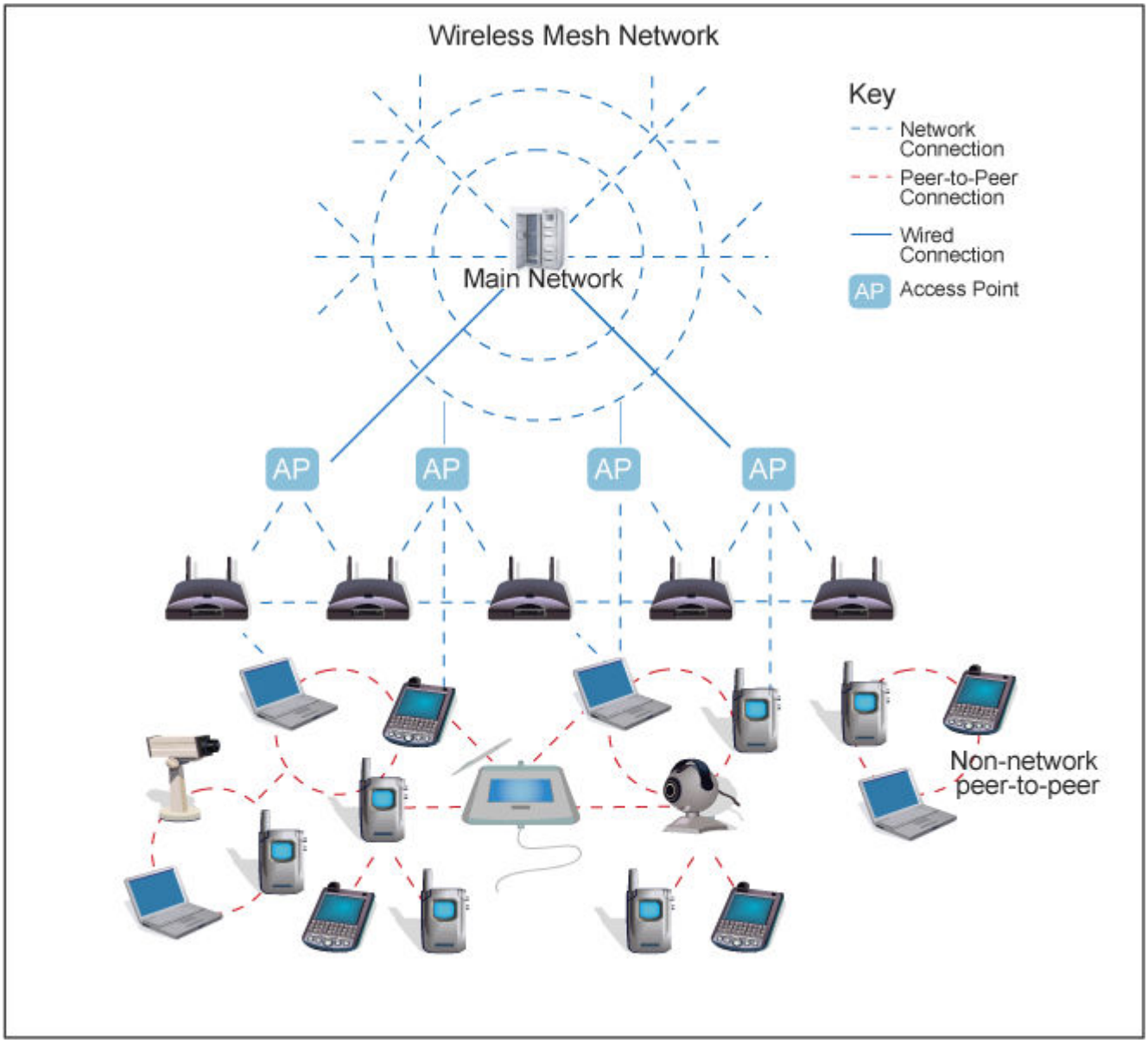
Wireless Mesh Network
Key
Network Connection
Peer-to-Peer Connection
Wired Connection
AP Access Point
Main Network
AP
AP
AP
AP
Non-network peer-to-peer

Figure 4

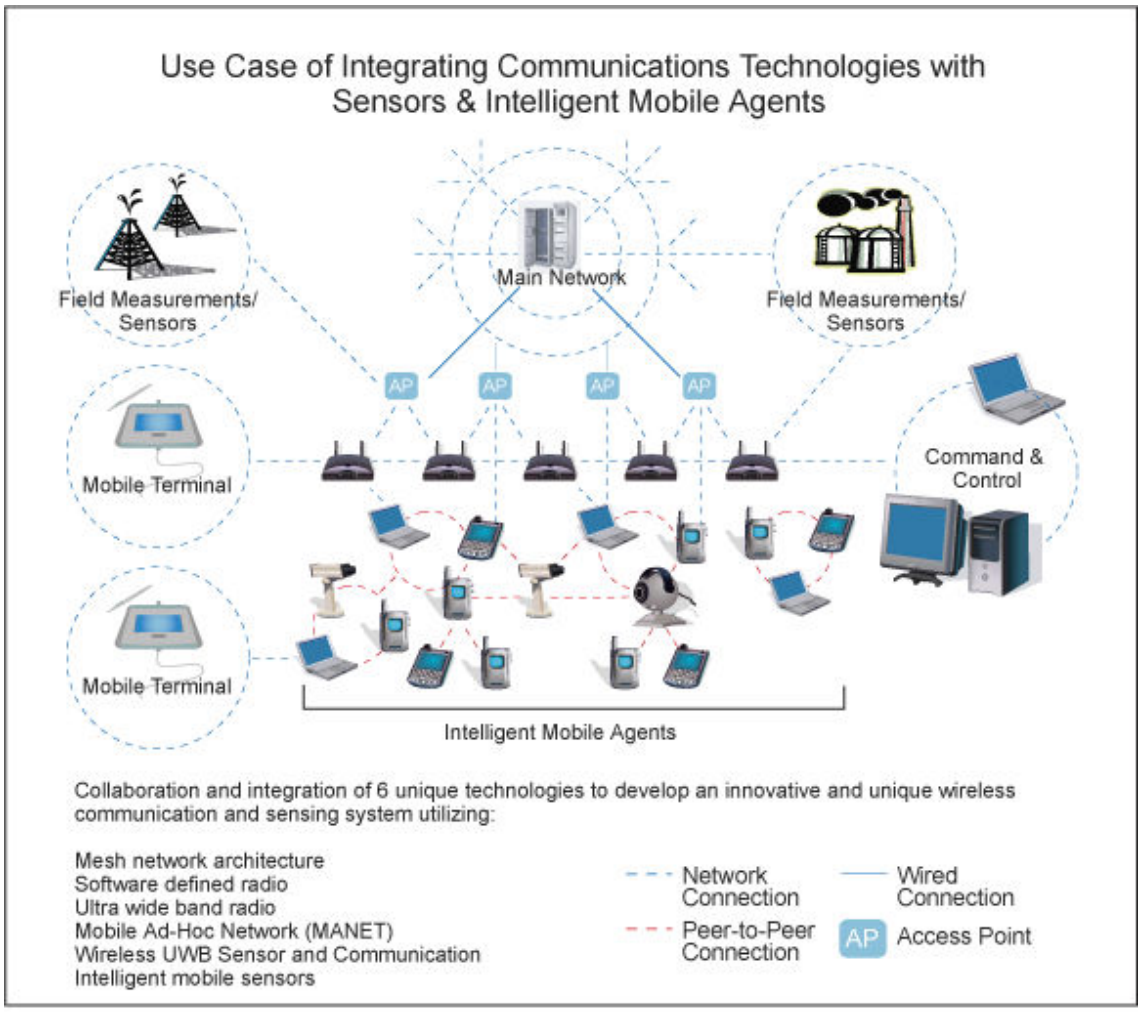

Figure 5

Conclusion

Recursion's *Voyager Edge* intelligent agent software solution embedded into a wireless mobile mesh network, software defined radio, and UWB enables a distributed knowledge network with an "intelligent" prioritization system that transforms the way to investigate, comprehend and respond to oil and gas field data being gathered remotely from widely distributed systems and heterogeneous sensor environments.

This intelligent, mobile agent based framework combined with the appropriate "intelligence", prioritizes processes among sensors and systems, sorting, analyzing and filtering data, to make "decisions" while automatically transmitting specific information in a dynamic, ad-hoc, wireless network to other specific systems, sensors or engineers and asset managers.

Voyager Edge can easily function on smart phones, PDA's, RFID devices, sensors, cameras, and other wireless devices as well as ultra-thin wired client devices. Furthermore, Voyager Edge also enables group and "nested group" messaging and peer-to-peer client/server/client relationships between wireless devices so that information may be passed among them without the involvement of a host computer.

Voyager Edge enables the next generation of, intelligent, digitized oil and gas knowledge networks. The resulting near-real time adjustments to changing field and plant conditions can save the operator significant time and OPEX, thus maximizing productivity from the oil and gas assets and short-handed asset teams.

About the Authors

A. Rick Habayeb, Ph.D. is the Information Technology Research Professor and Program Manager at Virginia Tech. Dr. Habayeb is directing several research projects in wireless secure communication, software radios, network interoperability, reconfigurable computers, real time systems and scheduling, collaboration tools, digital platforms, wideband and multi-functions antennas, and visualization tools and cluster.

He was the Command, Guidance and Control Technology administrator for the Naval Air Systems Command in Washington, D.C. He is recognized in the industry for his work in systems integration, partitioning, and effectiveness analysis. His extensive engineering background includes design of logic circuits and control systems, performance evaluation, reliability assessment, and analysis, systems architecting, and quantification of systems effectiveness. Dr. Habayeb has published several papers, reports, and a book entitled “Systems Effectiveness”. He previously served as Dean of the Faculty of Engineering and Chairman of the Electrical Engineering department at Yarmouk Univesity in Jordan. Dr. Habayeb has taught Systems Engineering courses at the University of Maryland and the George Washington University. He holds several patents in the field of switching circuits and data communication. Dr. Habayeb is a senior member of the IEEE and Sigma Xi.

Bob DeAnna, CTO of Recursion Software, has 22 years of experience in software architecture, engineering and mentoring. Bob’s expertise is in distributed and wireless application frameworks such as J2EE, CORBA, ATMI and J2ME. He has architected and developed applications and middleware in Java, C/C++, COBOL, PLI, and Assembler, hosted on operating systems ranging from MVS to Unix, Linux, Windows to Symbian and other embedded OSs.

Bob also is a co-author of a patent and commercial implementation thereof, for servers on embedded and portable devices such as PDA's and smart-phones. He has worked previously in numerous roles ranging from VP of architecture, senior consultant, lead engineer and trainer/presenter.

Bob received a BS in Mechanical Engineering from Rutgers University and a continuing education degree in C/C++ and Unix Programming from New York University.

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