SILICON VALLEY WORLD INTERNET CENTER

SMART ITEMS BUSINESS FORUM
WORKING GROUP

SENSOR NETWORKS IN THE PETROLEUM INDUSTRY: A TECHNOLOGICALLY VIABLE PATH . . . OR JUST HYPE?

MONDAY, OCTOBER 27, 2003

SUMMARY

BACKGROUND

On October 27, 2003, the Silicon Valley World Internet Center convened the second session in an on-going series on commercial usage of sensor nets. Under the aegis of the Smart Items Business Forum, this Working Group focused on the viability of sensors and sensor networks, and its underlying communications networks, in supporting industrial control and other business applications within the petroleum industry.

Some proponents of this technology have argued that it can greatly reduce the cost of providing data connectivity in industrial control situations. If data connectivity is substantially cheaper, then it should open up more sensor and control applications that can lead to overall process savings, improved reliability, reduced emissions, and so forth. Around these new control and monitoring applications, new business processes and new enterprise-scale applications will be needed.

Petroleum processing and distribution is an example of a high value industry that has processing plants and pipelines spread over large geographical areas in very harsh environments. The cost of providing data connectivity is considered very high. This Working Group session focused on the technology requirements for out-door control and monitoring capabilities in the oil industry, as well as the potential uses for sensor networks.

Participating in the Working Group were:

- Aether Wire & Location, Inc.
- Dust, Inc.
- Motorola, Inc.
- PARC (Palo Alto Research Center)
- SRI Consulting Business Intelligence, Inc.
- DaimlerChrysler Research and Technology North America, Inc.
- BP Plc
- Hewlett-Packard Laboratories
- SAP Corporate Research
- Sun Microsystems
- Cogenia Partners LLC
- Intel Research, Berkeley
- Silicon Graphics, Inc.
- VoltaFlex Corporation

INTRODUCTION

The Working Group focused primarily on insights of the key subject-matter expert, Mr. Mike Bean, Senior Technical Consultant with the CTO's Office of BP Plc (formerly known as British Petroleum). His presentation and subsequent comments covered a variety of needs and concerns around the use of sensors and sensor networks in the petroleum industry.

Mr. Bean's electronic presentation may be accessed on the World Internet Center's site at: (http://www.worldinternetcenter.com/Programs_and_Pubs/index.htm).

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The Working Group discussed the viability of sensors, sensor networks, and low-powered, battery-based communications systems. This summary reviews that discussion and the key insights from Mr. Bean.

Mr. Bean began by explaining that what BP wants from sensor networks is to discover the state of things, including their position and the possibilities for controlling them.
What his company and industry need are the following:

- It must be safe (of paramount importance).
- It must be maintainable.
- It must be practical (e.g., changing of batteries frequently would not be acceptable).
- It must help provide for security of their systems.

AREAS THAT ARE – OR COULD BE – USING SENSOR NETWORKS IN THE PETROLEUM INDUSTRY

The following summarizes key points made by Mr. Bean in the discussion around current and possible uses of sensor networks in the petroleum industry.

Asset Construction

- Drilling Rigs: Drilling rigs are complex to build and to maintain. Mr. Bean expressed that they want to have their rigs coded with RFID tags during construction. Those constructing the rigs would have some advantage in tracking parts, as would the maintenance people.

- Supply Chain: BP is considering tagging their lubricant supply chain, which is their only outwardly-facing application. Barrels of oil would be tagged, especially given their relationship with large retail companies moving heavily into the RFID space.

- Rail Cars: BP tows chemical cars all over the country, full of dangerous and expensive material. They are interested in exploring the value of sensor networks to track these trucks and to ascertain the status of their position in the process of acquiring and delivering products.

Tracking of People at Industrial Sites

Mr. Bean underlined that BP is de-manning their refineries systems quite extensively. Whereas they previously had hundreds of people on site, each with their own wheel to turn and section to look after, now they have very few people on site. Although they are skillful people and they may not know all the pieces of the equipment, they are skillful enough to pick up the instruction manual for certain pieces of equipment and go and deal with it. This potentially puts workers at risk for being alone and for not being completely familiar with the equipment. He concluded that the industry needs systems that have the ability to call for either emergency help or for information in a very quick turn-around time, either from a control center or from a health center. Additionally, there is a need to monitor the permission for workers to be in certain areas.

Tracking of Assets

"If we could find equipment and spares – stored both in yards and on plant – at the drop of a hat, we could save quite a bit of money," explained Mr. Bean. He went on to paint a picture of the large sites of oil rigs or refineries. The company rents a lot of equipment. He feels they tend to lose things on site. For example, refineries need scaffolding to get to areas for repair or maintenance. Every time they replace a valve or an adjustor – anything above ground level – they need scaffolding. The scaffolding needs to be set up, tested, the job completed, and the scaffolding brought down and stored. If they could track scaffolding with attached sensors, this would help greatly.

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His other example included the tracking of cylinders and of cargo. He noted that the tagging of cylinders can prevent fraud and malicious handling of barrels of oil. It is potentially a very large savings. He referenced BP's current remote monitoring of LPG tanks with low satellite monitoring. Mr. Bean commented that this is a very simple system, which has improved their delivery process.

Facilitating Other Business Processes
Mr. Bean commented that there are areas where sensors could facilitate a variety business processes. For example:

- Monitoring levels: BP sells liquid gas. These containers need to be continually monitored and filled. BP has added sensors to transmit information about the level of a particular tank so that when it gets below a certain level, they know to replace it. He underlined that if there is anything that we can know at a distance and get handled, that would be a cost savings of interest.

- Ability to measure additives and to have them remotely injected.

- Flame detection: ability to measure it at a more sophisticated level than is currently done.

DRIVING NEEDS FOR THE USE OF SENSORS AND SENSOR NETWORKS IN THE PETROLEUM INDUSTRY

Streamlining Processes
"Every point at which we can collect more data, more information – and use it properly – we can cut down the duration of processes . . ." Mr. Bean emphasized that being able to monitor the location of assets and of people in a time-efficient manner saves money. Beyond that, being able to raise the level of safety for its workers through such monitoring is paramount to BP. He added that, "If we can make processes much tighter, we can cut weeks off that. We can build money, real money back into the system. We can avoid a lot of costs – and control things better in the process."

During the Working Group the question arose: If things were cheap, or a moderate cost, would people do more of the same processing or would there be completely new applications – business applications – that would extend the use of sensor networks beyond control applications?
Mr. Bean commented that his colleagues' first choices are to make current systems better: faster, safer, more efficient. Once that occurs, then the petroleum industry can get more creative about additional applications. As an example, Mr. Bean noted that every time a process takes place that involves movement on something in the mesh of pipes at a refinery, someone needs to walk to each valve and turn it off. It takes a tremendous amount of time. If well-placed sensors were available to shorten this necessary process, this would be of great benefit.

CHARACTERISTICS OF MODERN DATA COMMUNICATION AND INDUSTRIAL CONTROL TECHNOLOGIES USED IN REFINERIES AND ALONG PIPELINES

The following summarizes the key characteristics concerning data communication and industrial control technologies used in the petroleum industry. Per Mr. Bean, the current characteristics are:

- Around saving money
- Using the investment made a hundred years ago and trying to get the most out of it
- Almost all have used the old "bus technologies" but these are getting old
- The transition from copper
- Aging of junction boxes
- Powering systems over an old network – the copper carries power to the sensors, which is a problem for wireless services

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Intrinsic Safety Considerations
Any use of sensors or sensor networks needs to embrace the considerations of intrinsic safety and meet the standards. "Intrinsic safety" is the biggest hurdle to any system, mechanism, or tool used around a refinery or pipeline. There are five basic standards in the industry concerned with things going wrong – whether in an explosive atmosphere, in a dust atmosphere, or other. The standards are set by government with varying classes of intrinsic safety (e.g., Class 2 is very easy to achieve; Class 1 is harder and what most refineries want to achieve, but do not need all the time). Within those standards, there will be four variants of gases: i.e., no gases present; occasionally present; often present; and when there are always explosive gases. The particular one of concern within refining is the incendiary spark standard, which controls the way something is made: if dropped from a height it must not break apart and must not possibly give a spark.

The alternative to "intrinsic safety" is an enclosure standard. This means putting something in a metal or high-density plastic box so that it can resist any pressure within the box. As Mr. Bean pointed out, the problem for a mote would be that it cannot send a strong signal out of the box. Therefore, the antenna has to be outside the box – which itself needs to be improved. If all that comes together, it would now be considered an intrinsic safety device and useful to the industry.

Temperature Considerations for the Communications Systems
The circuits that are in place now use fairly standard wiring. They go through areas that are particularly hot and have asbestos insulation. Mr. Bean noted that they can insulate almost everything they need to in order to guard against temperatures which range from –40C to 1000+C.

Noise Considerations
It is very noisy at these sites. However, the oil industry has communications systems built in to deal with this level of noise.

Latency for the Bandwidth of the Communications System
Participants in the Working Group questioned how often do "things" in the refinery or pipeline need to get measured and how is the latency for the bandwidth. Mr. Bean explained that it depends on the process. Some things get measured every day; some every hour, but not down to the milli-second.

Fiber: Alternative to Copper for Data Communication
Mr. Bean noted that glass fiber is being used in some places as an alternative to copper for data communication. At BP, they use a hybrid system. He feels that fiber may not be as expensive, in the long run, as was originally thought. However, there are some drawbacks in that a company needs skilled people to lay it and there is a downtime to dig the holes. A participant from the Working Group asked about the merit of laying a network that sits above the traditional communications network that can send a richer data set, avoiding, potentially, the problems of animals eating cables and water seeping into electrical and fiber optic cables. Essentially one could replace telemetry systems with wireless. Mr. Bean countered that it is not a problem with the medium, but with the protocols. One is limited in the kind of information that one can send over such a system. With that thought, he underlined that everyone would like to put out more sensors into refineries or pipelines and that there is a big demand for more data and accurate data. But it does not matter to them whether it is wirelessly communicated or not.

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The Challenge of Increasingly More Complex Communications Systems
According to Mike Bean, "We do have sensing on a variety of our systems: we use those in a logic feedback way more than a control feedback way to plan particular operations. If those sensors go we actually get to become less effective than we would be had we not had anything at all . . . The effect of those failed systems is catastrophic." Our subject-matter expert explained that as these already complicated systems get put into place, there will have to be more complex systems behind it optimizing it. If that fails, the consequences could be very serious in terms of safety and costs.

Real-time versus Delayed Data Transfer
A Working Group participant asked how important is the real-time communication aspect of the sensor data to the petroleum industry. In other words, would it be feasible, given business needs, to have the sensor collect the data and store it locally, then the communications systems convey it later. Mr. Bean responded that they would prefer to have both real-time and delayed data transfer.

WIRED VERSUS WIRELESS COMMUNICATIONS SYSTEMS IN THE PETROLEUM INDUSTRY

Driven primarily by the Working Group participants, a lengthy discussion ensued regarding the pros and cons of both wired and wireless communications systems. The short response from our subject-matter expert reflected that he is not "wedded" to the notion of a wireless network, but that he, more importantly, wants to have sensors that work and whose data can be communicated in a reliable fashion. The following summarizes key questions and discussion points.

Motivations for Using Wireless Networks
A main advantage of wireless over wired is that the company does not have to dig up the ground to lay in copper or fiber. For example, in a refinery, one might not be able to dig up the ground for nine months as there are shut downs only from time to time. Additionally, it is very expensive to dig up a site. For example, a BP location in Texas was quoted $12 million for the cost for re-wiring. It would be much cheaper to have a wireless communications system. A Working Group participant suggested a hybrid system of wired and wireless communications, depending on the environmental situation. He noted that if one had a sensor moving around, then one would have to have a wireless network to support it. Mr. Bean countered that this would not be a normal use of sensors for them, therefore not warranting, necessarily, an investment in wireless. Another participant pointed out that in the case of a malicious attack, having a redundant network of wired and wireless components could be very useful.

Another Working Group participant outlined the benefits of a wireless network, noting that if one has sensors and control networks with very low-cost wireless networks, then one can afford to put sensors and control elements everywhere (e.g., on all those control valves to see what way those valves are turning). Ultimately, the company would get much richer sensor information than from a wired, static network and it would have much better process control and better productivity out of the system. He speculated that the company could do that – at worst case – for the same cost for a control system, because what the company is spending for more sensors, it is saving on the wired infrastructure – with, ultimately much higher returns. Several participants shared this perspective.

This discussion wrapped up with a participant noting that an oil company could install one whole network of wired and wireless communications to handle each eventuality. He underlined that it is not a matter of wired versus wireless networking, but rather inter-networking. He called for an "inter-networking standard," where all sensors speak the same language. With each business application the company can decide if it requires a wireless or wired solution. There may be a

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30% efficiency gain with wireless; if there is no efficiency gain, use wired. A wireless sensor tomorrow may be much more efficient that a wired sensor today. He strongly called for the oil industry to prepare their entire networks to understand one language.

Reliability of Wireless versus Wired
Mr. Bean pointed out that safety officers are petrified about using anything other than wire (i.e., copper). They simply cannot afford to miss crucial data being transferred. The problem is that most refineries were built over 15 years ago. Much of the infrastructure is very old. This is at once a challenge and a burden, as the cost of doing something new is daunting and the onus on new systems is to always be better. Without knowing ahead of time whether wireless networks will be necessarily better, there is a natural tendency to stick with what works, even if it is old. Mr. Bean pointed out that it is up to suppliers to prove that new things are as good as the old systems or technologies.

Trusting 802.11
Many of the refineries and chemical plants at BP use 802.11, but they currently are being used for information systems. There is only one system being used for control: during down times when engineers are working on specific pieces of equipment. Mr. Bean noted that his company is interested in using 802.11, but right now it is not really a communications protocol that would be trusted fully. He did note how effective 802.11 has been, but that there are problems in getting intrinsically safe access points.

WHAT ADVANTAGES AND DRAWBACKS WOULD COME FROM AN AD HOC RADIO NETWORK THAT IS SUPPORTING THE SENSOR NETWORK FOR THE OIL INDUSTRY?

Mr. Bean pointed out that BP finds ad hoc networks very useful. Normally, there are very few people on a site. But during a shut down, there may be 2-3,000 people there. They operate in little villages set up around the projects that they are working on. A lot of processes could be enhanced with an ad hoc network where things are in a non-production mode with a temporary nature.

A participant pointed out that the biggest advantage is that installation costs go way down. Maintenance people can scatter sensors around. From a safety aspect, one can have multiple paths to network, with lots of different sensors – if any one device fails, other parts can fill in.

IF THERE WERE DRAMATIC COST REDUCTIONS IN PROVIDING SAFE, RELIABLE DATA COMMUNICATION FOR PETROLEUM INDUSTRY ENVIRONMENTS, HOW WOULD IT BE DEPLOYED?

A lengthy discussion surrounded the consideration of cost versus value. If the cost of a sensor network could be dramatically reduced, would the oil industry go for it? Mike Bean pointed out that "Every chemical engineer would love you for it. They want to optimize every part of their process – from waste water management up to catalyst replacement." But, realistically speaking, there are serious cost considerations in a technical arena, which is still so unsure that the industry is remaining cautious, hoping for tested systems from other industries or from a few front-runners. One participant queried whether the cost consideration for the oil industry was around the sensors or the communications infrastructure? Again, Mr. Bean had to defer answering, noting that it is sometimes a leap of faith to buy into a new technology unless someone comes along and can prove, for example, how much it actually costs per thousands of units of measurement to get new data. But, he affirmed, no one really knows those cost structures yet.

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The Working Group discussed the value of data gained from the cheapest sensors versus the more expensive sensors and the concomitant communications infrastructure to support it. The cheapest sensors are in existing wells to measure the temperature. The most expensive measure some form of internal pipe corrosion. Mr. Bean speculated that complex chemical analysis sensors are probably the most expensive. He added that, at this point, the chemical engineers want everything and anything, regardless of the cost. As there are so few case studies to figure the cost of the sensors and their networks, the industry is dealing with a clean slate to speculate.

OBSTACLES TO ACCEPTANCE AND DEPLOYMENT OF SENSOR NETWORKS IN THE OIL INDUSTRY

Mr. Bean underlined that there are both environmental and financial concerns around sensor networks that hinder advancement by the oil industry in this space. A participant added that culture is the biggest barrier given that people are used to doing things a certain way in refineries that were, mostly, built fifteen years ago. Also, engineers' time is at a premium, so that even if all the instruments and systems were donated, it would be difficult to convince an engineer to give enough time to counsel everyone on needed changes. In such a low-margin commodity business as the oil industry it is difficult to embrace large changes when many of these companies are under pressure to trim costs.

CONCLUSION

At the end of the Working Group session, participants continued to ask the same question to Mr. Bean, the subject-matter expert from BP: will sensor networks be of more value because of new applications and processes they can enable, or because of their contributions to doing current processes better? The response from the subject-matter expert remained steady. He underlined that being able do the same tasks or processes cheaper and more effectively with sensor networks is of first priority for the oil industry. The secondary effect comes after having demonstrated that the risk is sufficiently low to afford doing something new. He expects that the advent of mobile, on-line, or occasionally connected devices (e.g., PDAs, PCs, etc.) will provide the basis of many processes and safety systems for the industry.

The Working Group probed whether Mr. Bean saw the integration of sensor networks into the oil industry as an incremental change or if it could be, indeed, the foundation for a fundamental sea of change in the economies of the industry. Mr. Bean responded with the example of using sensors to determine the quality and composition of crude oil throughout an entire tank. If this were possible, he posited that the industry could save lots of money. He cited an additional example of a new process using a floating catalyst, which needs to be monitored extremely closely, temperature-wise, over a variety of surfaces. It would be impossible to do without these recently developed sensors. He concluded that with multiple sensors that can withstand temperatures at nearly 1000 degrees, there could be significant changes and economies made.

Several participants called for the oil industry to lead in setting standards in the area of sensor networks, noting the huge complexity of the optimization process for petroleum is comparable to that of large supply chains in the retail space. Mr. Bean countered that the industry does not have the clout that a Walmart, for example, has wielded in the RFID arena. His final words summed up his overall stance during the Working Group: ". . . our individual refineries are highly-tuned 'beasts' using existing technology – they don't know what they want yet, because they don't yet understand what they could have." The education process – the push and pull between large users and vendors – needs to advance with solid, market-size-appropriate case studies exhibiting positive results.

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APPENDIX A
IDEAS FOR FUTURE SESSIONS AROUND
BUSINESS APPLICATIONS FOR SENSORS AND SENSOR NETWORKS

Participants were asked to offer their ideas for future follow-up sessions in the Sensor Networks and Sensor Technologies area.

DATA SYNDICATION
- How to share cost of installing system

OTHER POTENTIAL USERS
- Military
- Homeland defense

STATE OF ART STANDARDS
- Particular industry

ASSET MANAGEMENT IN RETAIL SPACE
- RFID and active sensor networks

SENSOR NETWORKS IN HEALTHCARE
- Hospitals, homecare

SUCCESS STORIES – FAILURES, TOO!

NEW PARADIGMS FOR WIRELESS CONNECTIVITY TO CARS
- Business cases
- WLAN, DSRC

ENHANCEMENT OF AUTOMOBILE THROUGH NEW, WIRELESS CONNECTIVITY

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