<u>**An interview with Dr. Sanjay Sarma, Chief Scientist of OATSystems Inc. and Co-founder of Auto-ID Center**</u>
By: Richard Sebastian, Research Analyst RFID and Auto ID, APAC

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Dr. Sanjay Sarma,
Chief Scientist

Professor Sarma is credited with defining and developing many of the standards and technologies that form the foundation of the commercial RFID industry. He is a frequent industry speaker and serves on the Board of Governors of EPCglobal, the worldwide standards body he helped create. Sanjay is also an associate professor of mechanical engineering at MIT. In 1999, he co-founded MIT's Auto-ID Center and has served as its Chairman of Research.

Professor Sarma is a recipient of the National Science Foundation CAREER Award, the Cecil and Ida Green Career Development Chair at MIT, the Ferry Award, the Den Hartog Award for Excellence in Teaching, the Keenan Award for innovations in undergraduate education, the New England Business and Technology Award, the Boston Business Journal Top 40 Executive under 40 Award and was selected to Business Week's 'e.biz 25 Innovators' list. He has over 50 publications in computational geometry, virtual reality, manufacturing, CAD, RFID, security and embedded computing.

Professor Sarma received a Bachelors degree from the Indian Institute of Technology, a Masters degree from Carnegie Mellon University and a Ph.D. from the University of California at Berkeley.

Richard: Can you please tell us more about OATSystems Inc. (OATSystems) and where does it fit in the RFID value chain? Could you also please elaborate which industries or sectors does OATSystems cater to?
Dr. Sanjay: Sure, OATSystems was founded in 2001 based on research done at MIT's Auto-ID Center. The company was first to market with an RFID middleware solution enabling many of the early RFID pilots and deployments. Since then we have extended this foundation technology with extensive device support, a visual design tool, a flexible deployment architecture and industry solutions. In addition, OAT has introduced enterprise-wide device management, data management, process management, application integration and reporting.

Most recently OAT has leveraged its experience, having over 200 deployments world-wide, and has focused on delivering packaged solutions for retailers, consumer products companies and industrial manufacturers. These solutions provide immediate value enabling companies to deploy RFID-enabled solutions with less cost, time and risk.

In essence we transform data captured by RFID readers into something 'real', in line with what our company believes, "transforming RFID data into value" where the real benefits of RFID can be reaped. OATSystems has applications for supply chain management, shelf availability, asset tracking, and work-in-process to help manufacturers like Hewlett Packard to streamline their

assembly line and supply chain operations. We have also provided RFID middleware and industry solutions for many large high profile companies from the retail sector such as Tesco and Best Buy which is huge here in the US, consumer products such as Kimberly Clark and Procter & Gamble, and as mentioned, industrial manufacturers such as Hewlett Packard, Tyco Electronics and so on. Those are the three broad areas where our product solutions are being used.

Richard: As OATSystems has been in the RFID business since 2001, what are the changes or differences that you see in the market demand at a global level, and are there any differences with the Asia Pacific market?

Dr. Sanjay: OATSystems has a long history in the new age of RFID. As I mentioned, it was actually founded based on work I did at MIT's Auto-ID Center in 2001 where we were writing software for RFID. Then in 2003, as you probably know, Wal-Mart came out with its mandate for RFID, and that's when we decided to be a very solution focused software company. If you look at a global level, there are some very significant changes since RFID actually took off with the Wal-Mart mandate. The first thing you'll notice is the standards 'war' is over now. The Gen2 air protocol is now widely accepted – that's one change. The second change is that last few years, the performance levels of RFID have improved significantly – a few years ago people used to worry about read and write rates for example, but now people are more concerned about business process improvement using the data. The third change is that asset tracking has really taken off and what you're finding is that more and more companies are leveraging RFID to keep track of their assets. In addition to Wi-Fi tags, you're seeing passive Gen2 tags being increasingly used for asset tracking purposes. Those are some of the broad trends we generally can observe from a global market perspective.

If you look at the Asia Pacific market, things are similar to a certain aspect, but what's interesting is there is a lot of innovation taking place. If you look at countries such as China, India, Southeast Asia and so on, these countries are leapfrogging the Western world when it comes to innovative ideas - the Hong Kong International Airport for example, with their large scale RFID implementation for baggage handling. Since many of these countries have manufacturing-based economies, asset tracking and supply chain related applications using RFID are growing rapidly.

Richard: What are some of the major challenges you foresee in 2008 and coming years ahead?

Dr. Sanjay: Most of the technical challenges are pretty much behind us. It's a new technology and the business processes in the enterprise need to adapt to gain benefits from it. Some individual companies are doing this in a very impressive way where they have RFID-enabled existing processes, and that's what I mean by my prior comment - Asia Pacific is leapfrogging the rest of the world in terms of uniqueness of deployment.

Richard: What areas do you think your company needs to work on so as to accelerate the company's growth rate in the RFID business?

Dr. Sanjay: Actually, I think some of our recent product and technology innovations are contributing to our growth. First, over the past couple of years OAT has been working on fundamentally new deployment architecture for RFID which is quite revolutionary. We call it a flexible architecture and it enables companies to run business logic directly on readers, controllers and central servers or any combination thereof.   For example, in some instances it may make sense to move most of the processing logic to edge devices or to split it between central servers and edge devices. This architecture has some important benefits for organizations. It can reduce the cost of the required IT infrastructure and increase application responsiveness enabling employees to identify and correct errors in real time. Additionally, by distributing logic to edge devices there is no single point of failure – if a reader or control fails it doesn't bring down the entire system.

Second, we have recently introduced OATenterprise enabling organizations with large-scale deployments to centrally manage, configure, provision and monitor their entire RFID infrastructure and associated devices. Finally, OAT has introduced packaged solutions enabling our clients to put RFID to work in their operations in less time and with less expense.

Richard: From what we understand, OATSystems has a very strong presence in the North American and European middleware market. How do you consider your penetration in the Asia Pacific market presently and are there any plans to make further inroads into this region?

Dr. Sanjay: Yes, we definitely have a strong presence in the North American and European RFID middleware market, but we do have a rather strong penetration in the Asia Pacific market as well.

Besides having a software development center in India, we see a lot of activities involving manufacturing facilities both in India and China. We expect to see an uptake in Asia Pacific; in fact we are beginning to have stronger partner collaborations with system integrators across this region. Looking into 2008, you will see us more and more in Asia Pacific. We are getting more interest from various sectors in this region, and more interestingly you'll be seeing us capturing a few big deals within the next six to eight months.

Richard: Could you share some of the latest innovations in the middleware technology? How does Low Level Reader Protocol (LLRP) affect the middleware market?
Dr. Sanjay: From a general perspective, LLRP will streamline the use of RFID and fundamentally simplify deployment.

Another innovation actually happening goes beyond the middleware; it's the ability to impact business processes in real time at the edge. As I explained earlier, with our flexible architecture our software can run right on the reader - given the reader has the memory and central processing unit capacity (as most readers today do). With this capability, we can move business logic to edge devices to support distributed processes such as shipping and receiving, cycle counting and work-in-process operations. It's a form of edge computing that we are seeing happen now in a very exciting way. In fact, my colleagues and I at MIT have always believed in edge computing and distributed computing. For instance, if you were to take a look at any one of the large-scale RFID projects we are doing – some of the business processing will run right on the reader and some on the server. Both the server and readers will complement and coordinate with each other. The beauty of that is when the network goes down, there will be no service disruptions – the reader can still continue operate normally; thus the overall RFID operations are not affected as processing is done across the network.

Richard: What are some of the critical success factors or key must-have factors to compete in the RFID ecosystem?
Dr. Sanjay: RFID is a compelling technology but, in order to use it efficiently, we need to understand the business process re-engineering that is required, we need to understand the radio frequency (RF) physics involved, we need to understand information technology (IT), we need to understand the applications – all these factors need to be thoroughly understood before RFID can be deployed in its full glory. If you don't have all that in place, then it is going to be very difficult even for the most basic deployment of RFID.

You need to be able to deliver solutions to meet demands of the current times, you can't just say you're a software company and this is what my software can do and leave it to the end user to figure out the rest. It just doesn't work; you need to be able to serve the end user all the way through deployment. The most important thing is to serve all the end user's demands when they deploy RFID. In this regard, I believe that to deploy RFID successfully there are three things to consider carefully:

First, you must have a good understanding of what business problem you are trying to solve. Once you understand this, I believe companies should first look for existing configurable packaged solutions before resorting to custom development. This will save them the time, money and risk involved in developing RFID applications from scratch. Secondly, companies should look to take advantage of the real-time nature of RFID. RFID really enables organizations to build sense and react systems that can error-proof many of their operations saving them from costly supply chain and manufacturing errors. For example, at OAT one of our clients uses our RFID solution to instantly alert operators when they put the wrong shipment on a truck. This point-of-processing application enables them to avoid prorogating errors further into their supply chain where they are more costly to correct. Finally, I believe companies should look for solutions using a standards-based approach to reduce the cost of ownership and ensure compatibility with their trading partners and other systems down the line.

Richard: What are your personal targets for OATSystems in the global and Asia Pacific market within the next five years?
Dr. Sanjay: One of my personal goals for OATSystems is to continue its leadership position in the RFID space – our aim is to be an unquestioned global leader and a 'thought leader' for software solutions in the RFID ecosystem. More importantly, we want to revolutionize the way companies can achieve business process change and benefit with RFID. The goal here is to enable companies to improve overall productivity in ways never before possible. OATSystems' has very deep roots in

this technology – not only do we want to be successful but we have a personal goal to make sure RFID as a technology is successful. It's a question of a leadership and loyalty to the see that the potential of this technology is realized.

Richard: Where does OATSystems' strength lie in the global or Asia Pacific market?
Dr. Sanjay: Our strength actually lies into several things. First of all, I believe our company is truly a very global company when you take a look at the ethnicity of our employees. I'm from Indian extract, we have many people from India and China onboard our team – in fact we have many people working with OATSystems from across Asia Pacific and the rest of the world. This gives us a very deep cultural connection across the globe – it allows us to better understand the market dynamics of different locations.

The second thing is that we are very well connected with the partners, both at a Global and Asia Pacific level. In fact, just taking a look in Asia Pacific alone, we have very strong relationships with our partners based in Australia, China, Japan, Singapore, Hong Kong, India – among the many in this region. This makes us have a strong presence in Asia Pacific.

Our third strength fundamentally is the fact we are able to adapt. As I mentioned earlier, we are seeing some of the Asia Pacific economies leapfrogging the Western economies. So we are seeing some very innovative things and furthermore, the deployment architecture that we see in Asia Pacific is actually somewhat different from the deployment architecture that we see in America. With the flexible architecture developed at OATSystems, it gives us a very strong ability to adapt to the Asia Pacific RFID market. We don't believe in just taking Wal-Mart's RFID deployment design and imposing it everywhere else. You can't just take the American model and force it down to our customers in Asia Pacific – our system is tailored to meet the needs of all end users. Theoretically speaking, we could be seeing in five years' time RFID-enabled cell phones. And for a matter of fact with a flexible architecture, we could incorporate this middleware onto cell phones to bring about a new form of RFID readers. This would change the way RFID operates and although in principle we haven't done it yet, OATSystems middleware can make this possible with a flexible architecture.

Another aspect where I feel OATSystems is ahead of its competitors is the fact that we have always championed for a standards driven RFID architecture. Through my role at the Auto-ID Center, I have founded and sit on the Board of Governors of EPCglobal – an organization with the aim of developing industry-backed standards to support the RFID initiatives. In terms of standards, we at OATSystems have contributed to the majority of the core standards found in the RFID industry. Furthermore, besides participating and contributing to these standards, we also incorporate most of the standards within our software solutions.

Richard: Considering you are one of the co-founders of Auto-ID Center which has revolutionized RFID as a technology for the commercial sector, would you be able to share some thoughts on what made you initially investigate this technology?
Dr. Sanjay: Yes, absolutely. I have a good friend at MIT – his name is David Brock. David and I used to work on robotics a few years ago. In these robotics projects we used to work on, a robot could be used to pick objects, and recognize these objects based on vision. This vision could be enabled through a camera for instance where it will take a snapshot of the object and do some processing to verify the type of object it is picking up. We just thought one day that it could be much easier if the object could just tell the robot, "Hey, I'm an engine block – I weigh 2 kilograms!". So we begin wondering how the object is going to tell the robot what it is. One way to achieve this is with barcodes but then reading a barcode through a line of sight is difficult especially when the object isn't in a fixed position. Then we thought, "what about RFID?" – it was already in existence for some years. However, at that point of time, tags were very expensive. Then I also realized the active RFID sensors in the market were too bulky and there were no real standards for RFID. So, that's when I spearheaded the initiative to start the Auto-ID Center and I came up with the concept of the "five cent tag" – I said eventually the tags will come down to five cents once everything was in place. That's how it all started and then Wal-Mart and P&G began showing interest. Now, after approximately 10 years, the five cent tag is a reality and that's the history behind my involvement with RFID.

Richard: Many believe RFID as a technology shows the greatest promise in the supply chain environment. Where do you think the current scenario stands, and what is your opinion for RFID in the supply chain over next 10 years? Do you think we will be seeing majority the RFID deployments switch to an open-loop system leveraging on the EPC Network by then?

Dr. Sanjay: Yes, indeed RFID in the supply chain shows immense potential. As you can see now, more and more companies are embarking on RFID projects to manage their supply chains. It is bound to continue to grow over the next decade for sure. As for open-loop systems, I believe most companies will eventually arrive there. Already, we see open-loop RFID systems in Wal-Mart, Metro and Sam's Club for instance, and many more companies are in the midst of spearheading RFID initiatives which are open-loop based. Then again, I believe we will also be seeing more closed-loop systems to manage their internal supply as well for applications such asset tracking over time. Asset tracking is becoming an increasingly popular option for many companies to manage their assets. I think at the end of the day, we'll be seeing both closed-loop and open-loop RFID systems hand-in-hand being increasingly used at companies.

I must add that RFID is also gaining prominence for many different applications – many of them being very unique and novel solutions. RFID is a technology that could make everyday human tasks much simpler. For instance, RFID could be incorporated into a regular cellular phone in the near future as I already mentioned. It will be more advanced than those near field communication (NFC) phones already in the market. The possibilities are boundless with the many ingenious solutions built around RFID. For example, my friend recently purchased a new car which uses RFID in a novel way to provide keyless access   With the keyless remote in close proximity the driver can unlock the car simply by touching the inside of the handle of the driver's side door. In fact, without ever touching a key a driver can start the engine, drive, or unlock the trunk simply by having the remote on him.

These sorts of applications are not 5 or 10 years away. Some of these innovations are beginning to happen, I have no doubt that cell phone enabled readers will become a reality within the next five years. AT the end of the day, I think applications for home automation or consumer orientated RFID for the benefit of everyday users will be more prevalent in the market.

Finally, RFID protocols can be used to communicate with other things like sensors. It's the same protocol – you might not be only using it for the tags but could also be used for other things, similar to Wi-Fi where you could use RFID to communicate with sensors. This too is already happening where we're already seeing those Wi-Fi based RFID tags and sensor based RFID tags hitting the market. Who knows, in the near future we could be seeing RFID used to control light bulbs. Imagine when a person presses the light switch, RFID protocols could be used to activate the light bulb. Today, we're using a wire as a form of communication between the switch and light bulb but tomorrow, wires could be a thing of a past and instead we could be using RFID integrated with sensor based systems as the medium of control for these everyday applications. It definitely is very exciting to see how RFID could be applied for all these applications – it could be used to reduce wiring cost, improve safety, make work easier and much more. We're just at the tip of the iceberg with what we can do with RFID as the potential of this technology is boundless.

Richard: Finally, will you be able to elaborate a bit further where the future of the middleware market is? As RFID as a technology is continuously evolving and a myriad of innovations are being introduced constantly, do you expect the middleware technology to play an equally important role as it does today?

Dr. Sanjay: Yes, the reason is that the middleware in RFID is much more complicated than what people generally think. It's not that easy to commoditize. The analogy I will use is that in the past, IT systems have never been able to touch reality. What I mean by this is, typically, IT systems interact with the outside world through commands from a person pressing some buttons on a keyboard, for instance. IT systems just couldn't touch the real world in real time but when you actually start doing so, you start running into some fundamentally new business processing that you need - they're like some reflex actions in your body. For example, when a person uses his finger on a hot stove, his brain doesn't tell the finger, "OK, you're getting hot, move". The finger has a reflex comes from a sensor that automatically says, "Move!". We're all born with these reflexes. What will happen is enterprises, people, and consumers will need to have these business processes - real time real world business processes developed, and these new reflexes will reside in this layer between big IT systems which are very slow and batch orientated. It's fundamentally a new layer that emerges with the use of RFID. Some people call it the "Sense and react layer". I think the middleware will be very fundamental in a RFID project, it will continue to grow and we have a lot of innovation left to do. This is one of the key reasons OATSystems continues to invest money in this flexible architecture because that's where we see our future. Just imagine five years from now, the cell phone has an inbuilt RFID reader. It could be used to track many things – let's use a bunch of

keys as an example. The person will just need to prompt his phone to search within his house for the missing keys and the middleware will prompt him on the exact location of the keys. That's a human business process. It's the same thing with companies where an employee is walking in the factory and his reader senses that a particular object shouldn't be there. The reader will automatically inform him on this and he can take the necessary actions to move the object where it should be. In another instance, a fire extinguisher service date has expired and the reader can automatically detect this and inform the relevant people about this. That kind of sensing is more of understanding the business processes for safety issues. All these reflexes are built onto the edge systems such as RFID readers in PDA's or cell phones, and intelligence will reside in middleware. Our flexible architecture has very good capabilities to deploy this edge computing middleware which has reflexes built in.