

EXPERTS QUOTED IN THIS 15-PAGE **SPECIAL REPORT**

- 1 **Sam Adhikari**, research and operations lead at a Sysoft unit that is partly focused on blockchain
- 2 **Kenneth Church**, CEO of nScript
- 3 **Michael Cromhecke**, CEO of Steamchain
- 4 **Trevor Curwin**, VP of energy of markets at the green energy data analytics firm Greensparc
- 5 **Joe Fitzgerald**, supply chain principal at Deloitte Consulting
- 6 **Arun Ghosh**, U.S. blockchain leader at KPMG
- 7 **Matthieu Hug**, founder and CEO of Tilkal
- 8 **Joe Inkenbrandt**, CEO of Identify 3D
- 9 **Philippe Labalette**, a senior project manager for process automation at Siemens
- 10 **Stéphane Lannuzel**, chief digital officer for operations at L'Oréal

- 11 **Alex Lightman**, CEO of TokenCommunities
- 12 **Stéphane Morel**, founder and CEO of Akeoplus
- 13 **Bhagat Nainani**, group VP of IoT and blockchain applications development at Oracle
- 14 **Joel Neidig**, director of R&D at the gear shop Indiana Technology and Manufacturing Companies (ITAMCO).
- 15 **Gil Perez**, senior VP of products and innovations and head of digital customer initiatives at SAP
- 16 **Krishna Ratakonda**, IBM fellow and CTO IBM Blockchain
- 17 **Martin Ruskowski**, factory systems research department head at the German Research Center for Artificial Intelligence
- 18 **Diego Tamburini**, principal industry lead for manufacturing at Microsoft
- 19 **Hans Thalbauer**, senior VP, IoT and digital supply chain at SAP
- 20 **Dave Vasko**, director of advanced technology at Rockwell Automation

IN BLOCKCHAIN WE



The technology behind the rise of cryptocurrencies is widely expected to bring 'a common source of truth' to manufacturing

Blockchain, the public but secure ledger that propelled Bitcoin to success, is primed to move into manufacturing. Early use cases are presenting themselves in aerospace and defense, automotive and pharmaceutical manufacturing, as well as in any sector that is already digitally well-connected.

Combined with other smart technology, blockchain enables improved monitoring of the entire supply chain and

makes it easier for multiple parties within manufacturing to work together. By using data from smart sensors, blockchain can help verify that products are authentic and that quality standards have been maintained during shipping without the need for companies to share private, proprietary information. Blockchain also can help establish machines-as-service and can enable automatic payment when performance metrics are reached.

"As we started to look at blockchain, we realized its potential to go way beyond Bitcoin," IBM's Krishna Ratakonda said. "Blockchain acts as a common source of truth, processing, organizing and connecting data in a way that was not possible before. People have started to sit up and notice."

"There's such a big market," ITAMCO's Joel Neidig said. "Every technology leader—IBM, Microsoft, Amazon—is going to be into it. Blockchain will eventually become a technology like the Internet. When the Internet came out, people said, 'Why would I need the Internet?' Now everybody needs it. Now business runs on the Internet. How you apply it—the connectivity, the software behind it—that's where the solutions will happen. The key is developing those first use cases and filling those out."

A quick primer: Blockchain is a decentralized register made up of endless, connected cryptographic blocks. Data is stored, time stamped—and automatically distributed to many servers at once. Security is a key value. Blockchain is tamper evident: Any change is immediately apparent to all involved. Where multiple entities are involved as on a multiple-tier manufacturing supply chain, blockchain creates a record of every transaction. If someone adds to the data, the widely distributed ledger shows when and where that addition happened. Some call it the "ledger of ledgers."

Yet, even defining blockchain can be a tangle. Technology? Platform? Concept? Infrastructure? Blockchain is not one single entity either. There are a number of blockchain protocols, the most well-known being Ethereum and Hyperledger, as well as three types/ways of using blockchain: public, private and semi-private/consortium.

"You ask three people and you get five answers," Micro-

soft's Diego Tamburini said. "At its very core, blockchain is a data model that consists of blocks that are linked. Perhaps the most common way to characterize blockchain is as a 'technology.' Specific vendors provide platforms that support the technology. For us, it's a platform and a tool development concept."

"The Army has blockchain; the Navy has blockchain; the Air Force has blockchain," said Ken Church of nScript. "These blockchains don't always work together. They won't work together unless they're coordinated to work together. There's no such thing as 'Blockchain, done, it works.' It's really a system, a process, an approach."

Sysoft's Sam Adhikari emphatically describes blockchain as a concept, not a technology.

"Like the Web was a concept," Adhikari said. "Blockchain is an open-data ledger where you can deposit the data, collaborate together and be completely confident the data cannot be changed."

Data is locked down

Security is an essential selling point. But Blockchain is not 100% secure: In 2016, one hacker exploited a weakness and tricked the Ethereum Decentralized Autonomous Organization system, siphoning off \$50 million in Ethereum, according to a 2016 CoinDesk article.

Still, "compared with a regular database, which is always vulnerable to cyber-intrusion, with blockchain it's almost impossible to alter the data," Adhikari said.

"Any blockchain application is distributed all over the network," he added. "Even if a hacker somehow gets into a server, any data alteration will render the whole chain corrupt and everyone will know. Because the data is replicated in many servers, in order to break into blockchain, someone has to break into many, many servers. The problem is: no one knows where all these servers are."

"Parts of the Internet are not usable now because people are not confident who they are dealing with," he added. "Blockchain makes the Internet absolutely usable."

Motivated by the financial crisis of 2008, the developers of cryptocurrencies sought to find "something that the banks couldn't screw up," TokenCommunities' Alex Lightman said at a recent blockchain conference in Spain. "The idea with Bitcoin is you are solving ... the basic idea of trust online."

In terms of importance to society, blockchain is at the same level as the World Wide Web, he said. "Arguably, it's going to give us Internet the way it was supposed to be—more decentralized... more secure, more private, more equitable, and more accessible."

Cause for snickering or investing?

If you listen to the blockchain buzz, there's a rush to catch the blockchain train.

"There's definitely a lot of hype on this topic," Deloitte Consulting's Joe Fitzgerald said. "We have a ways to go. There will continue to be hype. It's an evolving technology. People see the promise in theory and now people are wrestling with how to implement it in practice."

As of now, "blockchain is still immature," Tamburini said. "Sometimes it sounds like a solution looking for a problem."

"The hype will always be there," Adhikari said. "In the late '80s, early '90s, I was showing a demo to someone about Yahoo! and the name itself was funny. Everyone started laughing."

Martin Ruskowski of the German Research Center for Artificial Intelligence said tech firms are "afraid they may lose time on the market."

"In recent years, those who were able to establish the technology first were able to grow. With all platforms, there are benefits of scale. We see it with Facebook. We see it with Amazon. People are afraid all the benefits come earlier, so they are investing."

'Killer use case' sought

Beyond and behind the hype, researchers are figuring out how to develop and best use blockchain to solve manufacturing dilemmas.

"With technology like this, it's easy to get too excited," Steamchain's Michael Cromhecke said. SteamChain enables machine-as-a-service contracts on industrial equipment.

"It's not a question of will blockchain will become impactful but when it will start to gain momentum. There's a chance that rollout adoption will proceed at an exponential rate. Blockchain has the earmarks of a highly scalable system that solves a lot of challenges today without requiring everyone to be in concert."

People who ascribe to the 'fail fast' way of doing business are jumping into blockchain to see what works and, equally important, what doesn't work.

"Just like with the Internet and the dot-com bubble, some early blockchain concepts are going to fail," Neidig



Joel Neidig of ITAMCO



Alex Lightman of TokenCommunities

said. "Everybody is in agreement blockchain will be utilized in the future but with what applications?"

"Blockchain is living on data from the past," Ruskowski said. "Who establishes it early has a long track record of transactions in the blockchain. They gain knowledge of what is working and what is not working. The philosophy of 'try early, fail fast' is also an approach. Instead of investigating only in theory, they are investigating in their



Martin Ruskowski of the German Research Center for Artificial Intelligence

environment. They find out early what are the benefits and what are the shortcomings.

"You need that killer use case to get everyone to join," he said. "It's still the early days. It will take several years before we see major applications coming out and high-volume use. But we are starting to see that in the supply chain area. We are already starting to see production incentives."

As opposed to that solution looking for an ephemeral problem, "early adopters are often in supply chain networks looking to solve a problem they can't use another technology to solve," Neidig said.

Early use cases of blockchain are in industries and sec-

tors that are already functioning in the digital world with sensors and Big Data analytics.

"They already have the fundamental things in place to connect the physical to the digital, and they just need to change the digital technology they're using to get incremental benefit," Fitzgerald said.

Appeal is wide

Blockchain has applications for makers of pharmaceuticals, luxury goods and aerospace and defense products, as well as other high-value, high-risk, highly regulated products, Fitzgerald said.

The value added comes from uncovering and preventing tampering, preventing counterfeiting and identifying where, when and, often, how failures occur.

"Aerospace, car manufacturing and biomedical—those are very highly regulated industries where they need to know the data hasn't been tampered with in any way," Neidig said. "You can have sensors validating everything to a digital ledger that is not owned by any one entity."

Blockchain offers value in five distinct networks within manufacturing, KPMG's Arun Ghosh said. Those key five networks are planning, sourcing, making, delivering and returning, he said.

"We're finding enterprise blockchain being deployed, added on as a trust mechanism or trust layer behind enterprise systems, as well as helping ground the trust mechanism as an anchor to understand both supplier authenticity as well as product sort of verifiability."

Supply chain a natural fit

Blockchain has begun proving its value along supply chains where there are multiple users but not necessarily 100% trust. As supply chains have wrapped around the world, the need has grown for a better way to monitor and verify supply chain conditions and transactions. With blockchain in use among multiple suppliers, it's easy to determine where and when value was added or a failure occurred.

"Supply chain has grown truly global over the last 20 years, and supply chain-related blockchain activity has started to pick up," Ratakonda said. "A lot of the goods we buy are not made near us. They come from far away and change hands multiple times."

Blockchain is a natural fit for multi-tier manufacturers that want to monitor components from the original raw materials to the final product for authenticity and for conditions during transport.



Diego Tamburini of Microsoft

Accountability beckons in food and beverage industry

One IBM client that distributes beef products to restaurant chains loses 25% to 30% of its beef due to waste because certain criteria are not met during shipping, IBM's Krishna Ratakonda said, declining to name the client.

"Without blockchain, there's no way to trace that beef," he said. "No one is paying attention to whether the beef is being routed properly because there is no reporting of the data. The only way to know the beef has expired is when it's received at the distribution center, someone looks at it, sees the beef has expired and throws it out. There's a pretty good incentive for this supplier because when there is wastage, he 'eats' the cost."

By using IoT sensors and RFID tags, manufacturers can verify temperature automatically at certain points and the data is automatically entered into the blockchain, Microsoft's Diego Tamburini said. If the temperature rose or dropped out of spec during shipment, the wholesale customer would find out immediately and the shipment contract would be voided.

Ratakonda imagined a different, more productive scenario:

"If the supplier has blockchain, he can predict where and when issues are going to happen and take action early on. For example, if he knows there are 10 cases of beef and there's no way they're going to reach the end point in time (before the shipment is out of spec), he could divert that beef somewhere else so it could be used."

Blockchain, again paired with smart sensors and other technology, also can help food and beverage companies validate that their subcontractors meet production conditions.

For example, if brewery A contracted with brewery B to make beer using brewery A's recipe, brewery A could use blockchain to monitor and validate that brewery B followed the recipe, maintained temperature parameters and avoided fraudulent activity, Siemens' Philippe Labalette said.

"This makes it possible in real time for the producer to see how his batch has been produced today," he added. ☞

"The biggest application we currently see is use of blockchain in the supply chain context," Ruskowski said. "Blockchain is feasible where you have non-trusted environments, such as suppliers delivering parts and you want to have full traceability throughout your delivery."

Consider a large Tier One OEM shipping components to GM or Ford, Neidig said. Without blockchain and other smart technology, the OEM often is unable to trace the raw material it uses. Blockchain shows its value in those second- and third-tier supplier networks by adding a method to control and monitor the process.

"That raw material [may] come from China," he said. "How do they verify that it didn't have any conflict minerals (minerals mined in an area experiencing armed conflict where profits benefit the fighters) in it. That needs to be validated and verified. Without blockchain, it's a paper system. It's very difficult and time-consuming. The benefit of blockchain is mostly in that area where you lose control."

Using blockchain to track components and products in cross-border trade emerged as a key use case for an aerospace parts manufacturer, KPMG's Ghosh said. "We found a real tangible savings and productivity gain with blockchain in cross-border trade and the value of understanding between shipper, receiver, regulatory body, and customs brokerage. We were able to set up a fairly transparent mechanism of not just what was shipped and received but actually the documentation that flows from jurisdiction to jurisdiction, from country to country, as well as the recognition of value-added tax or duty drawbacks, which can now be computed using smart contracts."

Currently, most companies track products and components only at certain steps of the supply chain where they collect the data, Ruskowski said.

An inspector with a clipboard (or tablet) at a receiving dock checks the temperature of the milk or other product and enters a note saying, "Yes, the temperature was within specs at that moment," Tamburini said.

In the absence of blockchain, no one can verify if any of that data is altered, Ruskowski said.

"Blockchain has the advantage of the continuous transaction," he said. "You cannot take out data. You can check if the transaction is part of any change. You can always ensure the transaction is genuine."

In the food and beverage sector, better supply chain monitoring and tracking via blockchain gives manufacturers the ability to act quickly to recall a product, for example food, and companies can avoid lawsuits and bad publicity, said Matthieu Hug, founder and CEO of Tilkal, which describes its

Matthieu Hug of Tilkal



main offering as a digital identity platform organizing traceability across supply chain stakeholders.

“Nobody has an end-to-end view” of the supply chain at this point in time, Hug said. “If you want to buy a frozen product, nobody in the supply chain is able to tell you the temperature of this item from the time it went out of the factory until the time it arrived. One of the consequences of that is nobody is able to properly organize a

recall of an entire product.”

Oracle’s Bhagat Nainani said blockchain can also help medical and other manufacturers keep track of every asset and transaction in their operations with end-to-end, shareable, non-repudiable record-keeping.

With blockchain, every event or transaction in the supply chain is recorded in a shared ledger after it’s verified and agreed upon by at least two parties through a smart contract, he said. In manufacturing, the entire chain or just parts can be shared with collaborators.

“This is an area where we feel technology has a lot of promise because having this notion of a ledger that’s distributed and tamper proof, using applications such as track-and-trace or our lot-lineage, each trading partner, as they’re transacting with the other partner, can decide which aspects of their transaction can be shared with the broader business network (which can include regulatory agencies, the government and even consumers),” Nainani said. “Similarly, regulatory agencies want to know which tests were done, what clinical trials data were used before it was released, and things like that. Our track-and-trace and lot-lineage are directed toward that.”

Oracle last year started offering blockchain applications for intelligent track-and-trace, lot-lineage and provenance (which helps with unique device identifier compliance), intelligent cold chain and warranty and usage tracking.

“Blockchain provides a unique way of addressing these (applications) because it handles problems that were not possible to address before in an easy way, the main one be-

ing end-to-end visibility across the supply chain,” he said. “When we talk to large companies, what we find is they have visibility mostly into one level of their supply chain and they would like to share information and have visibility across it, but there’s no easy way to share information and even if it is shared, they’re not guaranteed that it’s easily verifiable.”

The verifiable nature of the information, and its resulting trustworthiness, can help device manufacturers do a root cause analysis easily because the information can’t be tampered with.

It can also save money in the event of a recall. Current practice is to recall every device to preserve a manufacturer’s reputation and provide an answer to skeptics. But with blockchain, since every device is traceable end-to-end in a tamper-evident record, only those devices that present a problem need be recalled.

“With blockchain, you actually have more trust in the transactions that are happening,” Nainani said.

Bhagat Nainani of Oracle



Collaboration will be easier

Within the aerospace, pharmaceutical and other industries, blockchain will make it easier for companies to work together. No company wants to be blamed for a failure it did not cause. The appeal can be especially strong for small companies that don’t have the deep pockets to rectify a problem they did not cause but yet may be blamed for.

“One of the reasons companies don’t want to work together is because of the trust issue,” Adhikari said. “Small companies are always worried they will be blamed for something that goes wrong in manufacturing. If an engine

App developers are on the case

Blockchain is not plug-and-play. ITAMCO’s Joel Neidig said blockchain “does take a whole lot to set up.” So application developers are getting into blockchain to develop platforms that simplify blockchain adoption. It’s a replay of the late 1990s, when HTML coding needed to be tamed and simplified so Web sites could proliferate.

“The blockchain ledger by itself doesn’t do anything,” Microsoft’s Diego Tamburini said. “You need an app on top of it creating new blocks (based on your business needs).”

IBM, Microsoft and numerous startups are developing offerings that will communicate with blockchain and help manufacturers achieve their individual business goals.

Simbachain, produced by Neidig’s company, and Microsoft’s Azure product aim to take the pain out of starting and managing a private network. “We’re providing API and templates for people getting started,” Neidig said. “We’re providing early use cases so people can hit the ground running. It takes some technical expertise. Just the understanding of how it works is a challenge.”

“The opportunity for us is to simplify the development of blockchain-based applications end to end,” Tamburini said. “We want to hide the programming, the scaffolding, the authorizations and the particulars so developers can focus on creating the business logic and smart contracts.”

Companies like Steamchain are working to develop applications tailored to clients’ problems and business needs. Early APIs and platforms also enable end users to easily access blockchain, similar to the way Web browsers, paired with an Internet data connection, allow users to access the Internet.

“One of our clients purchases machines and locates them at their vendors’ sites,” Steamchain’s Michael Cromheecke said. “The vendors run the machines and produce the parts the client needs. The challenge is when it comes to crunch time and our client is not getting what they need to fulfill their orders. They call their vendor and say, ‘We need this stuff urgently,’ and they get subjective answers, such as ‘We ran for six hours yesterday. We’ll get it to you.’”

“With blockchain and smart contracts, our client can see exactly what the machine is producing and pay as they go, based on production. That results in a financial performance incentive for the vendor.” ☞



Michael Cromheecke of Steamchain

has been manufactured and there’s a failure, the blockchain data can show during an investigation the root cause of the trouble. There is a way to trace back the audit trail.”

Within a manufacturing supply chain, pharmaceutical companies, suppliers and regulators can track and monitor production, Siemens’ Philippe Labalette said. “With this technology, we will be able to share batch parameters with different companies in a secure way.”

Counterfeiting will be harder

Beyond the food and beverage sector, blockchain makes it possible for manufacturers to trace products and components to more easily identify and prevent counterfeiting and certify products meet certain standards.

“We see efforts mostly in large companies ... in the automotive, pharmaceutical and food industries where you want to have traceability,” Ruskowski said. “It’s about traceability of quality. They want to monitor the whole supply chain and make sure the product they’re buying is an original product, not one with fake ingredients.”

There is a significant financial incentive to validate products and reduce knock-offs.

The total amount of counterfeiting worldwide, in products ranging from watches to defense equipment, reached \$1.2 trillion in 2017 and is projected to reach \$1.82 trillion by 2020, according to the 2018 Global Brand Counterfeiting Report.

Blockchain can help shippers track pharmaceutical containers in a way that is auditable and non-repudiable, Hug said.

By combining blockchain with data analysis capabilities, blockchain helps companies identify where thefts occur and reduce or eliminate counterfeit drugs, he added.

Fitzgerald chimed in: “For pharmaceuticals, for aircraft, you’re lowering the risk of counterfeiting and reducing the risk of doing excessive inspections, compliance and [maintaining] records of where things have been.”

In the future, someone about to buy a luxury handbag on eBay could type the serial number and learn where and when it was originally sold, who else has owned it and, most important, whether it is really the brand it purports to be, he said.

Custom, multi-component, high-value products also are a good use case for blockchain, Ratakonda said. Consider a circuit board’s complex chip, which likely includes designs from dozens of manufacturers.

“How do you then go back and ensure that each sales dollar gets accurately split among all those different com-

peting manufacturers,” Ratakonda said. Blockchain makes it easy to slice that financial pie.

Another model to come

Ruskowski's team at the German Research Center for AI has been investigating the possibilities for using blockchain within a self-contained factory and hasn't yet seen good use cases.

Within a single production environment where everyone is trusted, blockchain doesn't add value, he said.

“We found out it's not really true that blockchain can solve everything,” Ruskowski said. “It's feasible with a non-trusted environment with a limited number of participants. It doesn't solve every problem on the market. The technology is promising but it has some issues that have to be addressed in the future. Today's blockchain will not be the model we see on the market in the end. There will be another model.”

Greensparc's Trevor Curwin is skeptical that blockchain's application to power grids will ever do away with the middleman—because the complexities of providing power are so great, he said during a recent conference panel talk in Barcelona on blockchain technology.

It is possible blockchain technology could enable “a distributed network of suppliers that that you can then trust,” he added. But the models he has seen so far prove that “we're in early days,” he said.

'Everyone can see what is happening'

But even a factory working with just one supplier can derive benefit.

Blockchain makes it possible for direct, automatic machine-to-machine reordering and shipping of inventory, said Labalette, who works closely with the IC3 blockchain initiative. That initiative is based at the Jacobs Technion-Cornell Institute at Cornell Tech and is funded in part by a National Science Foundation grant.

Instead of a human keeping up with inventory needs, a machine using blockchain can automatically recognize that inventory will be depleted in a few days or a few months, order the replacement product from a supplier, and then enable automatic payment, he said.

“It's not only efficient but it's possible to have better tracking,” Labalette said. “We create an environment in which the performance data of the machine is collected in a way that all parties have visibility. When the data goes in, everyone sees the same version of the truth at the same time. Everyone can see what is happening and the financial calculation.”



Arun Ghosh of KPMG

Newfangled contracts envisioned

Another application is automated, performance-based contracts and warranties.

The value of smart contracts extends beyond track-and-trace to integrating accounts receivable with accounts payable for all components moving from the supply chain to a warehouse, KPMG's Ghosh said.

“Smart contracts are being used not just to understand where, what and when but also to actually push and pull events to trigger payments, or recognize revenue, and even put it into a journal entry in an ERP system,” he added.

Steamchain is positioning itself as a firm that can develop tailored applications, such as automated contracts, for manufacturers and others to use, Cromheecke said. In these use cases, blockchain tracks the production quantity and quality of what a machine makes and automatically causes payment to be sent based on performance.

In one hypothetical scenario, the first payment for a factory machine would be released when the machine archived a benchmark of 400 components per minute over 17 shifts; the second payment when the machine reached 500 components per minute over 30 shifts and the third payment when the machine achieved 800 components per minute over 30 shifts, he said.

This scenario would prove to be a very convenient and flexible alternative to the traditional site acceptance process that today is very subjective and short term, he added.

These use cases could be especially valuable in situations where Company A owns production machines being used by Company B to produce products for Company A, Cromheecke said. In this scenario, there's no need for human checking or monitoring and no opportunity for human fudging or stonewalling—the truth is in the blockchain.

“It's a very elegant way to deploy a business model that has proven successful in many other industries,” he said.

“We think it unlocks a world of possibilities.” ☞

Ilene Wolff contributed to this report.

Additive manufacturing primed for blockchain adoption

Blockchain in additive manufacturing (AM) offers immediate opportunities for military use, said Kenneth Church of nScript.

“We've been working with DoD for a while,” he added.

One of the first use cases will be to easily and securely replace broken or missing tools, Church said.

For example, the U.S. Army could place a 3D printer in a Conex box (a standardized steel shipping container) in a forward deployment, he said. If a part breaks, a soldier



Kenneth Church of nScript

would take that part to the Conex box where a technician could then download design parameters in blockchain to print a replacement part. No information would need to be stored within the Conex box itself, eliminating the risk of what would happen if the box were lost.

“If I do that for a forward deployment, I can get a CAD file out there right away,” Church said. “The Army is seeing the benefit right now. Blockchain will be huge in helping move that forward.”

In general, AM is a prime place for blockchain because the process is already digitally driven and because the need is apparent. Additive will be a key driver in distributed manufacturing.

“Additive in and of itself is pretty digital,” IBM's Krishna Ratakonda said. “It starts with a model that is transformed digitally and then printed right there. That's definitely prime for enabling the technology.”

By using blockchain, manufacturers can monitor and even limit how many copies of a product or component are printed. That lessens or eliminates the possibility of, for

example, a customer paying to print 50 parts but actually printing 100 and selling the surplus on the gray market.

“3D printing is changing many industries,” Ratakonda said. “It used to be low-volume parts that were difficult to obtain. 3D printing is becoming much easier and higher volume. Typically, you own the design for a part and go to the designer to print those parts. But how do you know if he prints 100 instead of the 50 you authorized and the other 50 go into the gray market? Once the design is out there, how do you know who is printing the design or know who leaked the design? Without blockchain, none of these is traceable.”

“The manufacturer makes a big profit off the (3D printed) parts they sell,” he said. “Blockchain provides a guarantee and a way to track who accessed my design, and how many times it was printed.”

Church concurred. “If you guys are going to make this, I will know how many you are making and where they are going. That's huge from a vendor relationship (standpoint). Large companies will embrace this.”

Blockchain addresses the challenge of how to certify the product was printed using the original design and that the person who printed it had authorization, Microsoft's Diego Tamburini said. “You can avoid counterfeiting, which is a big risk, and ensure the provenance of that part.”

Identify 3D partners with several firms

Identify 3D is working on blockchain with Siemens, in terms of its relatively new AM network, as well as with SAP, IBM and others, Identify 3D's Joe Inkenbrandt said at the recent International Manufacturing Technology Show in Chicago. “I can't sell it today (in traditional manufacturing), because the quantities aren't big enough for blockchain to be interesting. In two years, when quantities are big enough, our system will move right into that.”

When distributed manufacturing does take hold, “it's going to happen quickly,” Inkenbrandt said. And when the average number of supply chain players rises to 30 from six, blockchain will “all of a sudden become really interesting.”

'Supporting mechanism' only, for now

In AM, smart contracts on blockchain could result in companies being licensed to produce X number of parts over X months and then being required to renew a license, Deloitte Consulting's Joe Fitzgerald said. “This is a supporting mechanism to improve the business model of various additive applications,” he said.

But be careful about betting the farm on early blockchain, he cautioned.

For example, “If your entire business model is about controlling how many times people can print things with your blockchain solution and you get it wrong and people can print an infinite number, that's a problem. It's a new technology. People dive in and make mistakes.” ☞

SAP, Intel, IBM, Microsoft, Dow Chemical, DMDII, L'Oréal, ITAMCO, Akeoplus, Siemens, Rockwell also try blockchain on for size



Hans Thalbauer of SAP

SAP piloted blockchain with 15 pharmaceutical firms, including AMGEN, AmerisourceBergen, Boehringer Ingelheim, GSK, McKesson, Merck and Novo Nordisk, SAP's Hans Thalbauer said in an interview at IMTS 2018 in Chicago.

The No. 1 use case for blockchain is all around track-and-trace: knowing where a product is and how it is holding up, he asserted.

In the six-month pilot that ended in May last year, SAP did one billion transactions on blockchain, SAP's Gil Perez said.

One lesson the SAP team learned: For drug companies, speed was less critical on the production side and more critical when unused drugs were being returned.

"The pharma use case we are addressing is prescription drugs' 'sellable return'," Perez said. "As such, on the production side it didn't matter if it takes another two seconds or 10 seconds to write the data to blockchain.

"Yet the performance is critical when the returned drugs are moving on a conveyor belt," he added. "The system needs to make a split-second decision on how to sort the drugs after reading and verifying the information from the blockchain."

SAP also recently partnered with semiconductor maker Intel to experiment with blockchain.

"In the high-tech industry, it's again the track-and-trace scenario: They are tracking their products, making sure that the components going into the finished product are serialized and can be matched and mapped," Thalbauer said.

"It's also the digitization of documents," he added. "For example, in the whole import-export scenario, there are thousands and thousands of documents that can be digitized. It makes life so much easier"—whether it is dealing with government officials or truck drivers.

"This [situation], where we still have a lot of paper-

work involved, is where blockchain technology, combined with today's super-cheap sensors, can automate a lot, making processes much more efficient."

Cargo ships will no longer sit in port for days waiting for paperwork. Digitized paperwork—that becomes part of a blockchain-based record-keeping system—"can take out 10 days in the shipping process," Thalbauer said.

IBM, Microsoft pick some partners

IBM is working with supply chain-related operations in the food and beverage industry. The company also has seen interest from aerospace and automotive firms, IBM's Krishna Ratakonda said.

Microsoft has engaged directly with customers in developing applications for its Azure platform to support specific blockchain use cases, Microsoft's Diego Tamburini said.

Microsoft also is working with Dow Chemical and The Digital Manufacturing and Design Innovation Institute (DMDII) on using blockchain for supply chains, he said.

L'Oréal testing two use cases

L'Oréal considers "connected products" a pillar of its digital transformation, L'Oréal's Stéphane Lannuzel said in a recent interview in Paris.

"It starts from a simple QR code that will be able to interact with your smartphone. It goes through RFID or NFC technology, and now even using blockchain. These technologies are there to make the link between the physical world, which is the product, and the digital world, which is the data and your smartphone. That's all the reflection around the connected products."

L'Oréal is testing two use cases for blockchain technology around transparency—concerning "the products, from



Stéphane Lannuzel of L'Oréal



Stéphane Morel of Akeoplus

raw materials to the consumers, and all of the logistics information," he said. "When you ship products from one country to another, you need to provide a lot of certificates, and putting the certificates in the blockchain is very promising."

ITAMCO does some government work

The gear manufacturing shop Indiana Technology and Manufacturing Companies (ITAMCO) got its feet wet with blockchain in a Defense Advanced Research Projects Agency (DARPA) project, ITAMCO's Joel Neidig said.

The company developed low-latency platforms to aggregate data at the machine level and push up to the blockchain only the data that was really needed.

Akeoplus sees new way to avoid disputes

In the fall of 2017, Akeoplus started an R&D program with CEA, France's Atomic Energy Commission, to explore blockchain technology, Akeoplus's Stéphane Morel said in a recent interview in Paris. "We are working with the scientists there to develop blockchain inside AkeoSpine," he added, noting that he developed that "gateway edge computing" software to include computer science and machine learning

in machines and robots.

The addition of blockchain will improve machines' traceability, he said.

"When you register what the machine is doing, for example, each second and record this data in a blockchain, it could be a very new opportunity for customers and suppliers to avoid disputes.

"You can't change the data written in the blockchain," Morel added. "So we want to include blockchain in our technology to help customers and suppliers be more efficient and transparent in how machines will produce in the future."

Akeoplus is working with "early-stage adopter customers" on the first version of blockchain inside AkeoSpine, which is just about ready to come out of the oven, he said, declining to name the customers.

Siemens explores the 'digital recipe'

Siemens, which has become a major player in blockchain's use on the power grid, is also working, via its Next47 unit, with use cases for blockchain in manufacturing.

The company is piloting projects in discrete and process manufacturing and working with the blockchain platforms



Philippe Labalette of Siemens

Hyperledger and Ethereum, Siemens' Philippe Labalette said.

About four years ago, Siemens began working with Identify 3D to further develop a protected, repeatable and traceable manufacturing process. Siemens so far has integrated the startup's software into its PLM system and automation equipment.

"Our goal is to enable distributed manufacturing: the idea that you can keep a digital recipe of how to build something and then manufacture it on demand," Identify 3D's Joe Inkenbrandt said. "Of course, the industry, like Siemens, wants to move this way, especially for high value, high precision parts in low quantities."

To address the problem of moving engineering further away from manufacturing, San Francisco-based Identify 3D focused on IP security, repeatability of standardization and production traceability, he said.

The company's software stores data about when a license was created, and for how many parts. It notes the serial numbers used, who designed the part, who made the part on what day, who the workshop manager was that day, and any design revisions. "That traceability becomes really important in distributed manufacturing," Inkenbrandt said, "because now that we've separated engineering and manufacturing, how do you know what your yield rate is?"



Joe Inkenbrandt of Identify 3D

"You can query our system and all that data is contained there so we can help build a digital twin," he added. "And then of course we can use blockchain to do it as well."

But blockchain only becomes useful when there are "a lot of collaborators" in a distributed manufacturing model, Inkenbrandt said. Today, with just six players in a typical traditional manufacturing supply chain, a centralized database using a trace application like the one in Identify 3D's software works just fine.

Rockwell Automation 'optimistic'

Rockwell Automation is taking a cautious approach to blockchain. The Milwaukee-based firm did some blockchain pilots with vendors last year, Dave Vasko said, declining to name any of them. For this year, he said, "we'll continue to look at what's developing and how we integrate best into that."

The company knows it does not want to own its own blockchain. "We're going to participate with other vendors and consortiums where required," Vasko said, adding that the firm is too diversified for one system to work.

"Leveraging standard tools for the infrastructure and being able to participate in different ledger schemes makes sense for Rockwell," he said in a recent interview in Philadelphia. "I'm very optimistic about it" in large part because blockchain technology will facilitate having "trusted transactions with much smaller companies" than those with which Rockwell partners today.

"We're trying to connect enterprises together," Vasko said. "Having small and medium manufacturers participate with trust is going to be a big change going forward." ☞



Dave Vasko of Rockwell Automation

Eight key blockchain challenges for manufacturers to overcome

1 Not born in manufacturing

Because blockchain was designed and intended first as a secure, public ledger for Bitcoin, some challenges have emerged with early applications in manufacturing, Microsoft's Diego Tamburini said. "Originally, blockchain wasn't intended for enterprise systems. Establishing smart contracts and integrating blockchain with new manufacturing systems is difficult because blockchain wasn't born in the enterprise."

2 Garbage in, garbage in

The fact that blockchain is immutable is a blessing and a bane. As multi-tier manufacturers move into predictive maintenance, they face the challenge of data sources that don't always supply information at optimal levels of quality, intelligence or transparency for true predictive analytics, SAP's Gil Perez said.

"The data quality is extremely important," he said. "If bad data goes into blockchain, it will stay there forever. Imagine different scenarios: if a car is not providing the right data mileage... if a half-million-dollar compressor doesn't provide the right hours of operation ... that will have a cascading impact on value of the call and maintenance schedule, etc. If the data is not correct, then everything you do you do will be built on that incorrect foundation with bad decisions being made. You need to start with the right foundation. You need to ensure that data along the chain from multiple systems is accurate, not corrupted, not manipulated, and continuously monitored."

Manufacturers should have a review process before writing data to blockchain, Perez said. "It will not eliminate all the errors, but hopefully will reduce them to a non-significant number."

If someone steals your blockchain key and uses it to add false information, there is no way to regain access or fix the incorrect data, Siemens' Philippe Labalette said.

Siemens is exploring "crypto signatures" to add another security layer to blockchain, he said.

A crypto signature will require all blockchain key users to prove they are who they say they are before they can make a ledger entry, Labalette said. The crypto signature technology relies on machine learning and hybrid blockchain technologies.

3 Neither a ginormous parking garage nor a fast highway

Blockchain is not the Kennedy Center parking garage for data. Blockchain is not the Autobahn for fast travel.

"It's not a database," Steamchain's Michael Cromhecke said. "You're not going to store all your Netflix videos."



Martin Ruskowski

Blockchain is not intended to be a storage mechanism for large data sets but rather for critical data verification."

Tamburini chimed in: "People trying to store a lot of data on blockchain are

finding problems."

In addition to being vetted, data should be screened for relevance before being written into blockchain, Perez said. "The attitude should not be, 'Let's write everything into blockchain.' Writing things into blockchain costs money. It's not free. There is a balance between brute force putting all information into blockchain and finding the minimal valuable set of data. Blockchain is not 'let's just stuff data in there'."

Speed is not a blockchain use case or selling point either. "The speed with which you can transact blockchain has historically been pretty slow compared with how you transact in manufacturing," Deloitte Consulting's Joe Fitzgerald said. "When you transact Bitcoin, it can take minutes for the transaction to clear. That can't happen in high-volume manufacturing."

Martin Ruskowski of the German Research Center for Artificial Intelligence noted that a public blockchain is naturally very slow.

"Everyone has to have all the information," he said. "It's not practical. Blockchain processes seven transactions per second worldwide. That's not sufficient for real-time needs like in manufacturing. The public approach is not feasible for this. You have to keep it in the local environment."

Sometimes, however, manufacturers don't need full-strength blockchain. Streamlining blockchain can make it faster: Call it blockchain lite, for some use cases.

In one pilot, SAP used what's called Multi-Chain blockchain—an open-source platform that helps users establish private blockchain—that doesn't support smart contracts. The result: a performance-optimized blockchain for a particular application that didn't require smart contracts.

"It's still immutable, distributed, decentralized," Perez said. "Using Multi-Chain in a permissioned-blockchain network, without smart contracts, was the right choice for this solution because it's much faster and less costly. The consensus algorithm is very straightforward. You optimize the blockchain for performance."

One data challenge now being addressed is off-chain storage and analytics, Tamburini said.

“Smart contracts cannot access external data without breaking the trust,” he said. “We are addressing that problem by allowing some code to run in the blockchain while maintaining the integrity of the blockchain.”

“If you are accepting an external database, you want to make sure that everyone who queries that database gets the same result,” Tamburini said. “You can’t do that if the database is outside the blockchain. That forces you to put data on the blockchain. But putting data on the blockchain impacts performance, especially if you have to replicate the blockchain across many sites.”

4 The middleman is still needed

One of the key advantages of blockchain is that it eliminates the need for a middleman—either a real person or software or technology—to verify transactions. But because there are numerous competing blockchain ledgers currently in play (including Hyperledger and Ethereum), middlemen are needed at least temporarily to integrate differing versions.

“There is an irony,” Fitzgerald acknowledged. “You have this ‘no middleman’ technology that now requires a middleman. But it’s a different kind of middleman. It takes the shape of a clearinghouse.”

Moving forward, blockchain will make it easier for manufacturers using different technologies to work together, Cromheecke said.

“Blockchain can be set up where multiple parties can create multiple opportunities to interact with the data without having to conform to a system,” he said. “You’re not expecting everyone to align with a certain data management regime. The data is universal. There are ways deployed to ensure that the data remains objective, is transparent to parties that have access to it, and highly secure from those who don’t.”

5 Tough for legacy systems, small manufacturers

Integrating blockchain into legacy systems and into companies that haven’t yet embraced the Industrial Internet of Things (IIoT) poses another challenge.

“We can’t say we will throw everything we have into the garbage and add blockchain,” Sysoft’s Sam Adhikari said. “We need to bring blockchain applications slowly into legacy systems.”

“Blockchain is a challenge for small manufacturers to set up, Ruskowski said. “What we see is the big companies will also be the platform providers. They are looking into it and they hope to be able to set up a platform like a modern bank or modern certification authority to be the interchange.”

“Users will need a subscription to Azure (Microsoft’s cloud computing platform) to get access to read and write to the blockchain,” Tamburini said. “Who pays for that subscription is a business decision just like what happens today when you need to read and write data

to a database. It could be the big companies who own the whole supply chain, or a consortium where everyone pays a little bit or pays proportionally. There is nothing in the technology to dictate that.”

6 Costly computing power needed

Companies using blockchain also will need robust and potentially expensive computing power.

“The scalability issue we see with blockchain is we need very high computing power for public transactions,” Ruskowski said. “Blockchain is mainly feasible for small-size groups of participants interchanging data.” “That’s going to a business decision,” ITAMCO’s Joel Neidig said. “For example, currently, to be a Tier One supplier to a large OEM could cost a small company \$100,000 to become compliant with the standards.”

“Some of these cases may emerge where the dominant player may need to pay to support their supply chain on the solution they prescribe,” Fitzgerald said.

7 Getting parties to share information can be difficult

When companies that are competing with each other are “all of a sudden connected in this distributed environment with the blockchain,” the idea of sharing information can be a show-stopper, SAP’s Hans Thalbauer said. “But more and more these days, they are willing to do that because people see the benefit.”

Broad adoption of blockchain tech in manufacturing is two or three years out, he said.

8 Standards still coming

Eventually, standards bodies will create new standards for blockchain. The National Institute of Standards and Technology (NIST) is “leading the charge on that,” said Neidig, who is part of the NIST blockchain standards working group.

In the meantime, smaller groups within industries are agreeing to use certain versions of blockchain ledger and particular smart contracts programs, Tamburini said. KPMG’s Arun Ghosh said some of these groups include the Trusted IoT Alliance and the Blockchain in Transportation Alliance (BiTA).

Certain industries, such as aerospace, already are starting to create informal standards, Fitzgerald said.

Along a supply chain, the dominant player would be the one to set up the servers and establish the blockchain to validate transactions, he said. “You naturally have the clearing house effect of who is controlling the integrity of the blockchain. Over time, that will shift to industry consortiums.”

“It’s hard to say which protocol is going to win the day,” Cromheecke said. “It’s not important which one does. Eventually, standards will emerge and certain technologies will win the day. That will be good and healthy.”



Subscribe to *Smart Manufacturing* magazine
Go to: www.SME.org/smart

