node. This would require the individual components to incorporate some level of agent-like intelligence whereby the condition of the computing node can be monitored and the component moved if failure is predicted.
One approach to incorporating intelligence is to map all of the parallel components of the task onto a set of agents such that the algorithm is essentially the payload of the agents. The set of agents then carry the payload onto the array of computing nodes. The array can be viewed as a landscape and the set of agents as essentially a robot swarm. The landscape comprises obstacles, which are nodes that have failed or are about to fail, and elevated terrain, where the height of the terrain reflects the load on the active nodes. The swarm can then move over this terrain to find an expanse where it can compute. Swarm pattern transformation methods (31) (32)[29] *can be employed both to avoid obstacles and navigate narrow terrain, but also to compact the swarm into a small area if needed.*
This approach provides a distributed alternative to one of the important yet centralized tasks in high performance computing, namely the scheduling of algorithm components to nodes. Further, if one of the nodes on which the swarm is located fails, a local adjustment can be made by the swarm agent relocating to a nearby part of the landscape and re-instantiating its dependencies. These two benefits of the swarm approach to high performance computing, which we refer to as swarm-array computing, offers the potential to improve the fault tolerance, and therefore increase the efficiency of high performance computing systems.
These concepts have been investigated practically through both a simulation and implementation (40) (41)[30] *The implementation employed a computer cluster with 43 nodes. Message Passing Interface (MPI) (42) (43)*[31] *implementations, namely Open Message Passing Interface (OpenMPI) (44) (45)*[32] *and adaptive MPI (AMPI) (46)*[33] *built on Charm++(47)*[34] *were used as the middleware for the implementations. A parallel summation algorithm with fifteen nodes was implemented using both the classical approach and the swarm-array computing approach. The main conclusion of the implantation studies was that the swarm-array computing approach improved fault tolerance as measured by the mean time taken for reinstatement of the algorithm if a node failed. A further conclusion was that the existing middleware for high performance computing doesn't easily support the swarm-array computing concept. Notably, a number of workarounds were required to realize the implementation.*

7 - manufacturing

improvements in American manufacturing competitiveness couldn't come at a better time. The global demand for manufactured goods is on the sill of the greatest expansion in history. Massive increases in demand are coming not only for today's goods, but also for entirely new kinds of products currently in development.
Measured in money (not percentages, since it's the quantity of money that directly determines buying power), the world's GDP is forecasted to expand by nearly twice as much over the next 20 years as it did in the past 20. This means at least twice as much growth in demand for everything from cars and aircraft, to tractors and chemicals, to clothes and computers. All of these things will be fabricated, all of them will be more complex than in the past and, thus, all of them will migrate to more information-intensive production systems.

Add to this the emergence of entirely new types of products yet to be manufactured. The rise of the internal of things (IOT), which will on the back the existing internal-much as containerization rode an existing infrastructure-requires the manufacturing of trillions of sensors and "smart" devices. One of the biggest and perhaps most significant IOT markets will entail healthcare. In the near future, bio-electronics and transient electronics (think in terms usefully "consumable" computers). Will likely lead to an industry as big as today's $3trillion silicon-electronics sector.

In addition, researchers and developers are pioneering uses for new types of exotic materials, not least among them graphene and carbon fibers, as well as so-called metamaterials (materials that exhibit properties that don't exist naturally). And even though it still seems fanciful, dozens of firms, from start-up operations to industry giant airbus, are developing air taxis, which means that soon yet another new industry will emerge to manufacturing them. Finally, if the private sector space entrepreneurs are right, and commercial space travel becomes a real industry and not a niche, there will necessarily emerge yet more new manufacturing enterprises to produce all the specialized hardware.

With all of the above, the low-cost producer has an enormous advantage as always. For any manufacturer, competitiveness and growth are served best not by cheap labor but by superior technology. Fortunately, the manufacturing sector has long exhibited the power to put new tools to work once they become practical. The technologies surrounding robotics, in particular, are rapidly advancing for manufacturing applications. The same technologies are now also reaching a kind of tipping point for use in the service industries.

8 – The coming robotification of services

Venture-capital investment offers a window into the kinds of technology that will drive future productivity gains, here we see, in the CB Insights tracking of robot investments. That service-oriented – rather than industrial – applications dominate, with 80% of the $3 billion of venture capital in the past four years put to work on next-generation robots. Investors made bets on companies developing robots for retail, warehouse, delivery, laboratory, educational, surgical, hospital, rehab, safety, security, environmental monitoring and social applications. Clearly, innovators and investors think that services represent a great opportunity for success.

Infusing software into hardware-to make true cyber physical systems, such that they become functionally, invisibly and reliably part of the world of atoms-is challenging. Unlike the purely cyber world, the physical world has things like inertia, friction, gravity and non-linear random events, all with serious safety implications. The real (as opposed to virtual) world cannot tolerate the equivalent of frozen screens, reboots, video jitter or iterations of software upgrades to clean up sloppy code rushed to market. But cyber physical technologies are improving rapidly, and we have already seen "first fission." But long before we see practical general-purpose robots, we will see commercially viable task-specific ones for applications across the service sectors.

9 – for any manufacturer, competitiveness and growth are served best not by cheap labor but by superior technology.

A proliferation of prototypes can be seen already, including some early commercial products for applications ranging from warehouse and delivery services, to firefighting and rescue work, to the pentagon's robotic "mule" program for carrying heavy gear for soldiers. The "mule" program has slowed, in large measure because such general-purpose machines remain both too expensive and too noisy in the field, the robot equivalent of the Model A has yet to be sold.

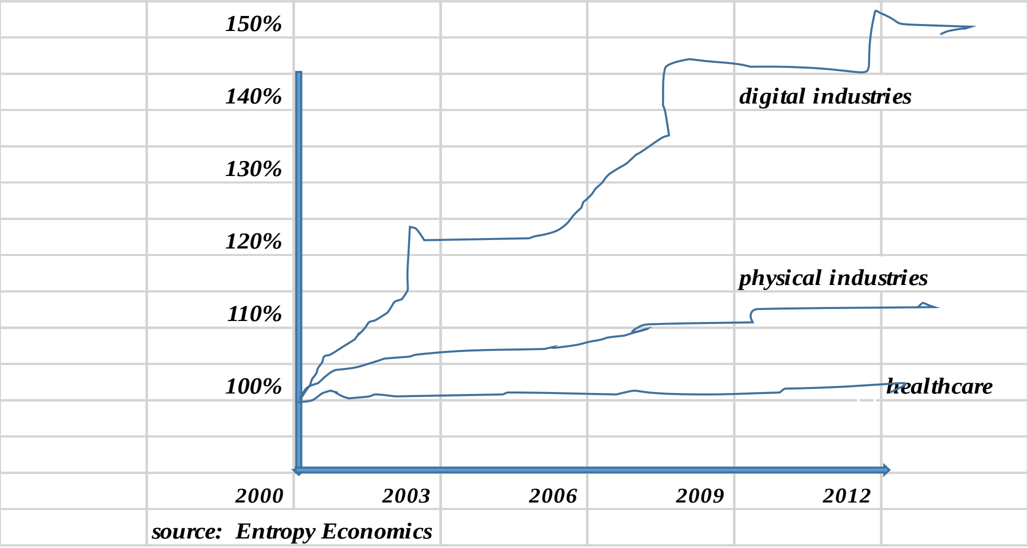
However, practical Model A's, if not Model T's, are already in use in homes, hospitals and warehouses, where comparatively light tasks and proximity to power sources make battery-powered robots viable. The more specific and narrow the task, the simpler the cyber physical challenges and the less expensive the machine. Six years ago, Amazon spent $700 million to acquire robot-maker Kiva for its wheeled, turtle-like, pallet-carrying warehouse robot, and Amazon has been sponsoring an annual contest to see whether robots can grab jumbled products from a bin and put them on a shelf.

Other types of service-specific machines are starting to appear, still mostly prototypes but some commercially available. While surgical robots continue to be a significant early market, we see applications for service-related tasks in security, safety and environmental monitoring and assessment, general-purpose cleaning, hospital disinfection and self-driving wheelchairs.

A total of 10 million service robots are already sold annual around the world, though 80% are robotics vacuum cleaners, with most of the balance either robotic lawn mowers or light-duty drones. The forecast for 60 million low-cost service robots sold annually before 2030 anticipates engineers succeeding in conquering performance and cost challenges in a broad range of applications. But the inflection point is now in sight for a trend that began with history's first modern household washing machine a century ago. The emerging panoply of service robots will be directed at all applications, not just domestic chores and entertainment.

10 – better labor productivity can bring down soaring healthcare costs

Improve labor productivity is long overdue for many services, especially healthcare. As tech analyst Bret Swanson has usefully summarized, over the past 15 years, healthcare productivity- value added per labor-hour- has remained stagnant, while productivity in physical industries has improved by about 15% and productivity in digital industries has improved by 50%.



The absence of real progress in service labor productivity is clearly visible in the net result. Consider the changes in cost of goods versus cost of services in America over the past 20 years. While the prices of childcare, education and especially, medical and hospital services have increased by as much as four times the rate of inflation, the real costs associated with the production of physical things (e.g., cars, computers, furniture and food) have either decreased dramatically or, at least, not outpaced inflation. That's the magic of productivity gains, which most service-centric activities have yet to experience.

It's an old maxim in economics; if you want more of somethings, make it cheaper. The inverse also applies; rising costs depress people's ability to acquire the desired product or service and collaterally depress the potential for (productive) employment growth in the industries providing those products and services.

Of course, educators and employers are eager to have access to people who are familiar with technology, but many of the skills they are seeking do not require a STEM degree.

digital twins can do more than bring efficiency and productivity to supply chains or machines; they promise radical improvements for complex systems or processes including, not least, for healthcare and medical procedures. In principle, with sufficiently granular information, a digital twin could predict a particular medication's impact down to the cellular level. While what has been termed the" virtual physiological human" remain aspirational, other service-related and manufacturing processes are already viable. adoption of this technology is in the early stages. At the beginning of 2018, only 4% of manufacturing companies has operational virtual twins, but almost 30% said they planned to start trials in the coming 12 months.

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