Case 91

The Super Formula and Super Antennas

This article introduces new mathematics that shape The Blue Economy, which is known as ZERI's philosophy in action. This article is of part of a broad effort by the author and the designer of the Blue Economy to stimulate open source entrepreneurship, competitiveness and employment. For more information about the origin of ZERI <www.zeri.org>

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The World Market for Antennas

The world market for base station, fixed outdoor and indoor antennas was $10 billion in 2009 and is projected to reach $13.3 billion in 2014. Antennas for the defense sector are growing faster than any other, and is already worth 1.2 billion with an annual compounded growth rate of 13 percent. Wireless communications have made antennas an indispensable component in computers and micro-electronics for residential, commercial and industrial facilities. This wireless telecommunication infrastructure will be worth $2.2 billion by 2014 as every phone, every computer and most homes in the developed world will be equipped with antennas in order to be connected to internet and cell phones. The global wireless base transmitting stations grew at 17 percent per annum between 2010 and 2011, and the multiband antennas even expanded at a double digit rate of 39 percent.

China and India are at present the largest markets in the world. However upgrades in the European wireless communication systems indicate that the Western European region could witness the largest growth in the years to come. The Kathrein Group from Germany is the world's oldest and the largest producers of antennas with 6,300 employees and 21 production centers with sales in excess of $1.4 billion in 2010. The Putian Antenna Company, a subsidiary of the Putian Corporation, is the leading Chinese producer located in Xian and specialized in the production of microwave, mobile, and satellite antennas. Kavveri, headquartered in Bangalore is the leading Indian competitor with a capacity to manufacture one million high-quality antennas per month.

The Innovation

The wireless industry has been studying how to make smaller and more powerful antennas with fewer dead spots while improving transmission speed. The industry is aware of the visual pollution and the increasing awareness of customers of the imminent risks from radiation. The standard antennas on the market today look like iron boards. The new smaller version proposed by Alcatel-Lucent, the French-US maker of

telecommunication equipment look like a cube, which has the advantage that these receivers and transmitters are small enough to be placed indoors and easily hidden from the view. The smaller size not only keeps the antennas out of sight, these antennas have a higher capacity for transmitting data and voice. Alcatel-Lucent claims that the performance will improve with factor ten, and will eliminate the need to have all phones within two to three kilometers of an antenna pole.

With the arrival of data hungry iPhone and Smartphone users, networks are stressed by demand. Even the best-established service providers are incapable of offering the 100 percent quality service, hence the notion and the acceptance of “dropped calls” by even the most discerning subscribers. Another major challenge the antenna market is facing is the interference between the different cell phone networks. As the number of subscribers in dense communication urban environments like airports, train stations, conference facilities and sport stadia has increased, it has become ever more difficult to secure clean connections for individual service providers. The only way that antennas guarantee that the signal is heard is to “shout” louder, by consuming more energy. New antenna designs will therefore have to find ways to reduce the screaming, which in the end will ensures a better battery life for all users and lower energy consumption.

Johan Gielis excelled in Latin and Greek at high school in Antwerp, Belgium. He obtained a degree in horticulture and after meeting with Jan Oprins, he focused his career on bamboo, the tissue culture of tropical and temperate climate giant grasses. As his research advanced he experimented with the study of molecular markers and bamboo physiology attempting to unravel the metabolism. Since the early nineties, Johan became interested in the mathematical modeling of plants, bamboo in particular. In 1994 he started using mathematical formula in the description of natural shapes. In 1997 he generalized the “Lamé curves” through a new mathematical formula known today as the “Super Formula”. It was first published in 2003 in the American Journal of Botany. Since then approximately 200 scientific papers have references or used the equation that has become known as the Gielis-formula. Johan realized that his mathematical breakthrough offers one single equation to calculate any two or three dimensional shape. The myriad of imaginary geometrical forms, impossible to calculate and design with traditional mathematics, are now within reach working with only six parameters.

First Cash Flow

The superformula solves the problem of limited symmetry of super ellipses and super circles. Shapes like pentagons and starfish, triangles and rose petals, flowers and leaves can now be calculated in one single equation. The possibility to calculate shapes in this way permitted to rethink geometry. Circles and spheres, hanging chains, the trajectory of planets, the form of snow flakes, the contours of planets and galaxies, radio

waves, telecommunication networks, the formation of rocks and crystals all try to optimize area, volume and/or energy. Johan and his team have been exploring the consequences of these findings for applications in optimization such as the calculation of the shortest distance in networks. He went on to create Genicap, as a commercial company, which follows a licensing model, and the Simon Stevin Institute for Geometry as the research and education center, both with offices in the Netherlands while maintaining his part-time professorship at the University of Antwerp (Belgium).

Based on those insights, Johan's team started designing the next generation of antennas under the direction of Dr. Diego Caratelli, ensuring the highest energy efficiency, the longest possible distance and the least material use. He and his team realized that the Super Formula permits the design of a new class of super shaped antennas that can be produced to order at very low cost (one eurocent a piece) while operating in an ultra wide band characteristics. These antennas can even be made out of recycled plastics eliminating reliance on metals, especially rare earth metals. The nature of wireless systems and the interferences which can only be overcome through "shouting" by increasing energy consumption spurs the demand for accurate designs of enhanced access points. As these new antennas can further reduce in size, improve radiation, operate with broader bandwidth while being easy to deploy or install, Johan realized that one of his first business applications is the breakthrough design of antennas which have no resemblance at all with the present shapes.

The Genicap team has proven the viability of the super antennas. This could imply that the number of transponder towers that dot the horizon could be significantly reduced, dramatically increasing energy and material efficiency. These 3D antennas have no resemblance at all with the present cubes, iron board or pole-like shapes. The success of the manufacturing of these diatom-like structures relies on new technologies such as additive manufacturing and 3D printing (see Case 50). The use of mathematics, geometry and physics in order to increase productivity and efficiency of materials and energy is one of the hallmarks of the Blue Economy.

The Opportunity

The discovery of the Super Formula opens the world to a broad platform of innovations. The sector that is likely to be most affected is computing. Until now, the increase in computer chip performance depended on breakthroughs in materials, and the physical structuring of the processors. Now the breakthrough in the speed of computing is nothing else than the underlying algorithms which can be dramatically simplified using Johan's equation. When the visual presentations are resolutely moving towards 3D, the translation of a complex image into a binary code through the Super Formula can reduce the bandwidth required by a factor 100 or even 1,000. This means that the mere change of the algorithm releases tremendous computer power. For the first time we see how a mathematical formula permits a multifold improvement in performance without requiring any innovation in materials.

The implications are vast. None of the leading software companies from Microsoft, to Oracle or SAP have grasped the depth and breadth of the impact of the Super Formula on their existing core businesses. This however offers the opportunity to imagine a platform for entrepreneurship that could give rise over the years to dozens of new Microsofts. The power of Johan's breakthrough is that it unleashes innovation in anything from computing to communications, to packaging and water flow, manufacturing and distribution. It is this type of innovations that makes the Blue Economy what it is: an opportunity to transform the business models in order to transform society toward efficiency, sufficiency and perhaps even abundance.

Gunter Pauli is the author of the Report to the Club of Rome:
"Blue Economy: 100 Innovations - 10 years - 100 million jobs" published in 35 languages worldwide.

For further background on the 100 cases: www.TheBlueEconomy.org
For a day-by-day update on Blue Economy and ZERI follow Gunter Pauli on Twitter
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