World Sensor Organization

PROPOSAL

To create the World Sensor Organization, WSO, a global collaborative entity where scientists and engineers may contribute their findings, and methods, for sensors. WSO will try to transform proof of concepts to field deployable sensor *systems*. Successful sensor *systems* may be converted to market ready phase and implemented for designated use, if feasible.

VISION

Thousands of publications, perhaps millions, are generated each year on topics related to sensors. Scientists and engineers are producing laboratory versions of sensors for humans and healthcare, veterinary medicine, environmental and industrial purposes. From this wealth of knowledge, (see http://bit.ly/PLASMONICS) few sensors make it to the market, if transaction costs spell profit. What happens to the outcome of sensor related research?

It may collect dust or loiter in cyberspace or found hidden on the second page of Google search. Yet, critical issues for detection, which could save lives or improve the environment, remain unsolved. Translation from vision to market reality, is the rate limiting factor, for many sensor related research results.

World Sensor Organization (WSO) aims to partially alleviate this problem through a global consortia (center). WSO will catalyze the convergence of expertise necessary for the sensor to evolve as an integrated sensor *system* including, but not limited to, signal transduction/capture, data collection software, mobile interface, analytics, visualization, secure access via smartphone apps, delivery of information to the user, cybersecurity and transmission for global connectivity.

RATIONALE

The infectious enthusiasm for entrepreneurial innovation calls for confluence of multiple factors to create the optimum ecosystem. Few locations in the world are able to capture the key factors. Even fewer scientists and engineers possesses the attributes necessary to shepherd their research results to a market deployable product, or service, through the entrepreneurial grind.

Grand imagination often generates great inventions but too many good inventions die without a proper path to innovation. The latter may not succeed without entrepreneurial skills. We are left with an embarrassment of riches, millions of published papers and unpublished ideas, but the fruits of labor are few, and far between, because the continuum is difficult to coalesce. What can we do to drive more ideas to fruition?

Inventors are keen to patent their findings and rush to create start-ups. Stand-alone start-ups ignore the fact that a sensor, no matter how profound in scope, is simply a tool for detection. The ecosystem and local/global connectivity is germane to function. Sensor data/information must trigger action, based on appropriate data analysis after sensor data is available to the system. If the sensor data does not contribute to the decision, its value may perish, rapidly. The integrated system of systems, and transaction costs associated with each event in this cascade, reflects a convergence of technical issues with economics, which must be navigated, in order to arrive at a feasible solution, affordable by the end user and the end-user community.

Solutions, for example, GE Pharmacia BiaCore (old) and Genalyte (new), are marketed as high cost products, suitable for affluent users in wealthy nations (about 10% of the world population). Investors and inventors of sensors, are keen to follow the patent protected profitable path, vying for the 10% of the global population in US, EU and JP (approx. 700 million), in their elusive quest for personal wealth, as a reward for their imagination, invention and innovation.

THE ROAD NOT TAKEN

WSO wishes to "think different" but as an initiative in the US, its germination may face hurdles. World Sensor Organization (WSO) wants to remind the women and men, involved in sensor research, that their work, and outcome, may not have to bite the dust. There is a path to immortality. By contributing their research to WSO and pursuing a collaborative "open source" approach, for translating their sensor ideas, to a deployable sensor *system*, they may reap the reward of gratification, the reward for enabling science to serve society, the reward for their labor to improve quality of life, the reward for contributing to global public goods.

Few efforts survive in the public domain, without economic incentives. WSO is cognizant of this fact and wishes to introduce the financial reward named "Miss Moneypenny."

For every sensor event, triggered by every user, WSO will attempt to find a path to extract one penny, in profit, from every transaction. In other words, extracting 1 penny (US one cent) as net profit, by using the "pay-per-use" concept, we monetize "sensor-as-a-service" rather than the sensor-as-a-product, sold as an one-time product. By reducing the barrier to entry into world markets, WSO promotes social business entrepreneurship. WSO can penetrate the global market of 7 billion people. WSO envisions a paradigm shift from the product lifecycle mindset to arrive at the user lifecycle paradigm. The user does not pay for the product but pays for "service" as long as the user lives and uses the service based on this or related products. The product lifecycle may be 2-10 years but the user lifecycle may be 50 years. Hence, micro-payments and micro-revenue for services, provided as micro-payments, during the life of the user, ~50 years.

WSO "sensor-as-a-service" aims to rake in net profit of one penny per use, per person, per day. That translates to 700 million pennies per day, or US$7 million per day in revenue, if only 10% of the global population (700 million) uses a WSO certified sensor, once, each day.

ETHICAL GLOBALIZATION AND ETHICAL PROFITABILITY

In this example, the micro-revenue from ethical profitability, due to economies of scale, from only 10% market penetration, may exceed US$2.5 billion per year.

Development and modularization of product, segmentation of the sequence, work unit synthesis and structuring the alliances to aggregate the end-to-end ecosystem to capture the pay

per use billing granularity, are difficult tasks, but nothing that violates any laws of physics or thermodynamics. Hence, it is possible.

Micro-payment based pay-per-use service model can be applied to almost any product if analyzed and dissected with the tools of transaction cost economics. The billing granularity and evidence of use may be captured in a digital ledger. Unique id of each transaction may use the internet protocol version 6 (IPv6) format using a 128-bit hexadecimal system which is capable of generating 2^{128} or 340,282,366,920,938,463,463,374,607,431,768,211,456 or 3.4×10^{38} unique addresses [ref 13].

The technical convergence in combination with the business model paradigm shift has the immense potential to unlock the power of social business entrepreneurship. The benefits due to WSO may reach remote corners of the world. The barrier to entry is probably low enough to penetrate markets of billions where the per capita earning barely approaches US$1.90 per day.

One cent profit may be too much or too little, depending on the value delivered by the sensor data, demographics of the market and economic bandwidth of the end user community.

The micro-payment model is nothing new and originates from micro-loans and micro-investment practices. It is the dominant model for business wealth created by MacDonald's and PayPal. Grameen Bank of Dhaka, Bangladesh pioneered micro-loans to women, only. In recognition, Dr Yunus, Chairman of the Grameen Bank, was awarded the 2006 Nobel Prize.

Micro-payments may lead to mega-profits and the model is not limited to sensors. It can be applied to 3D printed automobile or aviation industry spare parts, transplanted hip or knee joints, bidirectional energy arbitrage, autonomous vehicle services, energy storage, home

appliances, jet engines, and security-as-a-service for modular, mobile, retail cybersecurity offerings, delivered online or purchased from a corner grocery store or neighborhood Walmart.

For related ideas, please explore "18.Commencement" which is a PDF in the zipped folder 'CHAPTERS' available from MIT Library https://dspace.mit.edu/handle/1721.1/111021.

FINANCIAL INCENTIVES

WSO proposes that [a] a quarter of the earnings are distributed to scientists and engineers involved in the sensor system development [b] a quarter of the earnings are re-invested in WSO and its affiliated institutional R&D and [c] a quarter of the earnings are used in projects to spur education and economic growth in the less fortunate nations (our future markets, the emerging economies, for example, sub-Saharan Africa) and [d] a quarter of the earnings are used to strengthen the WSO organization, its foundation or endowment, to ensure uninhibited progress.

WSO is a solution for the vast majority of the global sensor scientists whose work may serve humanity. Aggregating sensor data on open source platforms, with adequate cybersecurity and data analytic tools, will allow sensor information arbitrage in near real-time, at the point of need. What happens when we can measure? We can establish metrics, generate quantitative performance indicators, inform decisions to direct policy, structure appropriations based on information rather than the *pork barrel* approach practiced by politicians. Policy measures, if pursued ethically, can lead to social re-engineering of communities through distribution of social services, prioritized restructuring of access to healthcare, education and workforce development.

EXTENDED MISSION

WSO is an idea, which, if implemented, may change the world through ubiquitous sensing, at a cost which will grow the global economy, rather than sap its economy by charging $100 for a sensor. It will lift many boats, not just a few yachts. It will empower social business.

WSO will serve as an educational platform, for inspiring undergraduate and graduate students, to train for the steps necessary to transform ideas into reality. The collaboration of global scientists may enable paths to include rigor, innovation and exposure to diverse problems.

The potential for successful outcomes through WSO will remind students that completion of their degrees and graduation may lead to that proverbial "light" at the end of the tunnel. The impact of student motivation on graduation rates and research funding may be significant.

WSO may serve secondary education outreach. Almost every discipline, and their convergence, may be exemplified by sensors, sensor systems and sensor networks (similar to the significance of "energy" as a theme for science and engineering). In a manner similar to the Cisco Networking Academy (CNA), which commenced in 1996, as a high school networking lab project (I helped to start CNA at Thurgood Marshall High School in San Francisco, CA), WSO can help to start the Sensor Networking Academy Program (SNAP) in high schools, worldwide.

Hence, WSO is a tool for workforce development through SNAP for secondary and tertiary education. WSO may offer students a variety of opportunities for research in basic sciences, materials science, nanotech, biotech, medical instrumentation, electronics, ASICS, devices, systems engineering, embedded systems, sensors, time sensitive networks, signal transduction, networking, data, analytics, statistics, mathematics, simulation, computer science, programming, AI, telecommunications, cyberphysical systems, standards, cybersecurity and IoT.

BUILDING ORGANIZATIONS

World Sensor Organization is a grand challenge, an idea which will only grow if fertilized with credibility, cooperativity and collaboration. Global community of scientists and engineers, must work with industry, government and non-government organizations (NGOs). Support from the parent institution must be uncompromising and unequivocal.

Building the structure of the infrastructure, necessary to create this organization, in a sustainable manner, will require greed-free leadership. Individuals who are oblivious to not receiving credit, individuals who are dedicated to serve as an instrument, individuals who are committed to science as a tool for social progress, individuals who are not prioritizing personal wealth creation, individuals who believe in creating economic growth, individuals who are capable of excellence in communication across a very diverse spectrum of stakeholders, globally, at multiple levels, including science and engineering, engaging the public, as well as cultural respect, diplomatic finesse and political-context awareness. Building trust is the secret sauce.

As with any consortia, seed funding for organizational nodes may be quintessential for lift-off. The primary step is to build the foundational coalition with appropriate credibility and "hooks" to reflect the vision of the World Sensor Organization, at a global scale. Unlike traditional consortia, WSO may not operate on an "entry fee" mechanism, in order to uphold its claim for public goods. Hence, "joining" the consortia and "member finances" for the WSO, must be *separate* operations, *without* dependencies. This will make our task hard, financially. The leadership must remain cognizant of the steep path which we must scale for future success.

WSO members are expected to be individual engineers/scientists/students, institutions, NGOs, organizations, corporations, government agencies, governments, international standards bodies and associations.

WSO may be financed by gifts, seed funding, endowments, grants, foundations, and these categories (listed to show increasing amounts) "friends" ($1K+), "partners" ($10K+), "contributors" ($100K+), "patrons" ($1M+), "sponsors" ($10M+) and "donors" ($100M+).

Working groups (WG) and special interest groups (SIG) will be created to modularize and distribute the operations, starting with sourcing (when an idea is contributed) and extending to systems oversight.

Liaison with standards bodies may be required to ensure that the work and outcome from WSO is in compliance, or creates new standards, which must be interoperable with other existing standards, or possesses the requisite characteristics for pursuing global adoption.

WSO use cases for sensor research, development and applications must offer a broad portfolio, to attract membership from diverse industries and government agencies, for example, [a] machine, tools, 3D manufacturing [b] oil, gas, water, energy, desalination, natural resources [c] environment, communities, smart cities, sewer systems, emergency management systems [d] healthcare and medical IoT (https://dspace.mit.edu/handle/1721.1/107893) [e] Digital Twins in manufacturing systems, maintenance, transportation, aviation, (please see "04.Digital Twins" PDF in the "CHAPTERS" folder accessible from https://dspace.mit.edu/handle/1721.1/111021) and [f] agriculture including animal farming (micro-robots in cows to monitor metabolomics of lactation).

WSO may evolve in ways we may not anticipate due to the plethora of unknown unknowns. But, WSO must be capable of generating value from research, education, students and applications. The primary goal of the coalition is to advance research outcomes and promote education which can create new leaders, endowed equally with scholarship and leadership.

RISK

The central thesis of WSO is to "apply" the research outcome from scientists, and shape it through further R&D, to serve a purpose, which generates value through sensing. By connecting the sensor data with the sensor ecosystem, we make sense of the data and extract actionable information. The information may improve a function or performance, in near real-time. By connecting this data and/or information to real world situations or by connecting a "swarm" of sensors, we may optimize processes, workflows, automation or improve accuracy, and/or precision, of diagnostic, predictive or prescriptive analytics. Taken together, using control feedback loops or decision support, we deliver dynamic optimization, due to the sensor.

The central problem in this proposed concept of WSO is the assumption of the existence of trust and altruism, not only in sourcing the sensor idea or scheme, but also in working with the partners in the ecosystem, which is salient to the delivery of value from sensing to the end user.

[a] Why will an engineer or scientist trust WSO to contribute her/his research? [b] Why will the partners of the ecosystem (for example, manufacturing execution systems or MES) allow WSO to work with its systems? [c] Can we identify and define the transaction costs associated with each stage? [d] What degree of systems interoperability do we need, to uniquely track and trace every change of state, in order to bill the client for the service used, according to pay-per-use?

Question [a] is crucial. If WSO cannot be trusted serve as the global sensor research repository, then the central thesis is null and void. Explicit institutional support and the ability to bring together a team of pioneering global leaders, as co-founders, may be the first step to earn trust. For question [b], gaining agreement to create a few real world test beds with industry and corporations, may elevate the trust level. The latter may help to engage with governments and agencies, at home and abroad. Can we get a critical mass of pioneers to support the WSO vision?