MANUFACTURING AND NETWORKED INFORMATION SYSTEMS FOR LIFE SUPPORT

Govindaraj, T.
Industrial and Systems Engineering, Georgia Institute of Technology, USA

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Contents

Summary

The result of current agricultural practices, driven by the general trends in globalization, is increasing commercialization and the number of large scale farms even in developing countries that cater to the needs of the consuming countries. These include farms specializing in the production of meat, sea food, fruits, winter vegetables, flowers, and other commercial crops in Asia, Africa, and South America for export to Europe and the rest of the industrialized countries. Such practices are often wasteful of resources, and cause pollution, for instance via runoffs and insufficient utilization of nitrogen fertilizers. By reducing the amount of food grains available, they often deprive the people who need them the most. Large scale farming operations result in the growth of microorganisms with increasing antibiotic resistance and damage to the wetlands and mangrove forests, for instance, in India and Southeast Asia due to export-oriented aquaculture, and banana and coconut monocultures in the tropics, including Amazonian rain forests. The damage resulting from large factory farms must be quantified, and strategies must be developed to gradually lessen their negative effects on the environment.

The driving force behind globalization is the profit motive, which is also used as the single measure of success, with little awareness or consideration of ecological or other environmental effects and social consequences. The realization of the connectedness (or the lack of it) among the entities is often lost. Everything looks isolated and hence the overall context is lost, and most often invisible. Such a practice is clearly undesirable,

and often leads to unsustainable and wasteful growth. Networked information systems can and must be designed to make the relations and connections (and the interrelatedness) clear, transparent, and explicit. Measure of worth or value (of fundamental information) must be made available along many different dimensions (e.g., nature's contributions, pollution control costs, loss of biodiversity, social costs of dislocation, unemployment etc.). Means for comparing the various costs and information measures must be identified and built into the analysis and design frameworks. Distributed databases containing relatively static data and information on legal and regulatory matters, relationships (corporate information, organizational charts etc.), together with data on climate and weather, food production, pollutants etc. organized in a manner to offer the possibility of making information available tailored to the context are needed.

Increasing the local content in manufacturing, for the total cycle when possible, by doing most value added operations locally in a decentralized fashion must be explored vigorously. Localized production, combined with the use of waste materials locally for fertilizer and for energy, e.g., peanut shells, coconut husk, and wood chips, will not only reduce the pollution problem, but also reduce total energy and nutrient requirements. Decentralization of manufacture also has the potential to compensate for many negative consequences of increasing urbanization, e.g., increased employment and an improved sense of self. Renewable energy presents other opportunities for local self reliance and improved sustainability. Fuel is essential for food preparation, and is often implicated in the destruction of forests. The use of passive solar energy to the generation of electricity from photovoltaics, in a local and decentralized manner can help alleviate many problems discussed above.

The development of new manufacturing practices and the wide dissemination of proven techniques depends on the availability of knowledge and information, and needs to be kept up-to-date and presented in a manner that is easily accessible. Properly designed information systems are also necessary for linking and tightening the supply chain, distributing the design functions, manufacturing, service, and maintenance. Continuing research is needed to redesign the work and the means of production to make these a reality.

Information also plays a critical role in integrating advances in biotechnology for the well being of humans, both in the advanced industrial countries as well as in developing countries. For instance, genetic engineering techniques can potentially offer significant benefits in preventing, curing, and managing many diseases and chronic health problems. There is still a considerable degree of uncertainty about the possible consequences of employing such techniques, especially on the environment. Accidental introduction of harmful variants of many species is a major concern. Genetic manipulation is often claimed to be the solution to the loss of biodiversity. However, such an attitude can accelerate the loss by falsely ignoring basic problems. Nevertheless, the potential benefits must continue to be explored. One such example concerns a major health problem in the developing countries, that of a lack of sufficient micronutrients. The golden rice, incorporating beta-carotene, is claimed to be a cheap solution to the vitamin A deficiency that plagues large populations. Other possibilities include the production and delivery of drugs and pharmaceuticals via genetically modified organisms (GMO) capable of being stored and transported without refrigeration. Such developments continue to blur the distinction between agriculture and manufacturing, with information playing the key role.

1. Introduction and Overview

With the advent of the "information revolution" during the past decade or two, resource-, and labor-intensive manufacturing is now distributed throughout the world. Consequently, people in many developing countries have become increasingly exposed to manufactured goods, while simultaneously being influenced by the global broadcast media. There has been an increased tendency everywhere to adopt the cultures and lifestyles of the advanced industrial countries. Pressures on the environment and ecosystems have increased due to human activity, particularly resource consumption and manufacturing, affecting the long term health of the planet. Such a development is unsustainable, especially if the current rate of population growth continues. In this article, the role of manufacturing and information systems and their contributions to life support are examined.

A significant factor of life support that is generally taken for granted, and consequently often ignored, is the contribution of natural ecosystems. Some research activity within the past decade or two has been directed at understanding, modeling, and quantifying the diverse sources and influences of natural ecosystems on life support. This research has also been translated into a significant amount of work devoted to shaping public policy at the national and international levels, for instance, from the Law of the Sea to the Kyoto Protocol. This is particularly evident in a number of areas relevant for assessing the health of the global environment, for instance, the use of fossil fuels and the thinning of the ozone layer. While steps have been taken to lessen the threat to the ozone layer, the threat of global warming has continued, and means for carbon sequestration continue to be explored. Therefore, attempts to model and quantify the interactions and contributions from a wide range of sources and effects can be formidable, and are welcome.

There is a need to integrate the disparate research efforts and results, and adapt the methodologies to extend the models to include 'manufacturing' and 'networked information systems' relevant to life support. These include work on the understanding and the preservation of biodiversity, food and energy security, ecosystem services, and ecological economics. In addition to basic academic research, work by various international and non-governmental organizations (NGO) in education, research (both science and policy matters), and advocacy has made significant contributions. Notable among the NGOs include the Rocky Mountain Institute, the Worldwatch Institute, Stockholm Environment Institute, and Action Group on Erosion, Technology and Concentration (ETC group). A unified and easily accessible compilation of information from these resources can be quite helpful.

In this article, life support systems and the relevant aspects of manufacturing and networked information systems are reviewed, followed by an outline of a plan for integrating the results into an evolving information system useful to researchers, policy makers, and the lay public by organizing the methods, models, and systems.

2. Background

2.1 Self-sustained communities in relative isolation

It is instructive to imagine what life would have been like in a tropical island such as the Hawaiian Islands, Hispaniola, Madagascar or Sri Lanka, and go back in time several centuries, before Columbus 'discovered' America. While the inhabitants were by no means isolated from the rest of the world, the degree of isolation was almost completely total by today's standards. Interaction with the outside world was primarily comprised of an occasional ship ferrying spices or silk, or other exotic commodities from the East to the West. The pace of life was rather slow and leisurely, even though most of the population of the islands was likely to be poor compared to the current material standards. An agrarian, hunter-gatherer, or sea-faring lifestyle meant laboring hard to support themselves, and perhaps tending their farms and livestock. People lived in relative harmony with nature, taking only what they needed and husbanding their environment in a sustainable manner, even though this was not universally true. Their needs were simpler.

Societies were fairly self-sufficient and people lived in general harmony with nature. Even if they wished for a luxurious and overly consumptive lifestyle, the technologies available at that time were not conducive. Many of the "needs" tend to be created by lifestyles induced by the technologies themselves. The wisdom of the native peoples everywhere cannot always be assumed to be benign, however. One cannot be certain that they were positively supportive of the natural world, nor were they always in peace with their neighbors. One only needs to look at the (rate of) extinctions of certain birds in Hawaii, for instance, at a rate comparable to the worst among recent times to arrive at this conclusion.

Nevertheless, life support depended almost entirely upon locally available sources. The geographical isolation and the distances were made vast by the limitations of available transportation, together with a lack of suitable communication and information infrastructure, guaranteed this. This meant not only the basic human needs for food and shelter, but also the medicinal and recreational needs to keep one healthy in body and mind. Over time, the isolated populations were selected out, leaving only the people fit enough to survive the rigors of everyday living. Life expectancy was, however, relatively low and productive life was fairly short.

2.2 Increased mobility and the evolution of manufacturing

As transportation and other allied technologies improved, improving mobility, the needs and the demands on the environment began to change. Life support itself became more than the basic needs of food, clean air, water, clothing, and shelter. Since air and water were available in plenty, relatively speaking, the society had only to be concerned with food: cultivated, or hunted (and gathered) on land, or harvested from the oceans. The tools used had likely evolved over many millennia, along with skills in their use. Distribution and storage too were simple: limited by what could be consumed before spoilage set in, with some processing to extend the "shelf life," and/or traded within a relatively small geographical region. "Manufacturing" was centered around food, for instance, to build the artifacts and tools required for obtaining, processing, storage, and transportation. The information and communication systems concerned with life support were rather simple, and were centered around satisfying essential physiological needs and for surviving the dangers posed by animals and hostile neighbors. In fact, these systems had little to do with immediate life support needs, except for possible life-threatening diseases or conditions where external help could mitigate the danger. Such systems probably played a minor role in the lives of an average islander.

Manufacturing, in the current sense of the word, evolved from scratch, except for operations related to building and maintaining farm implements, fishing nets etc., almost all of them locally, to something much more sophisticated. Dependency on non-local resources began to grow, which then requires information. In spite of the wide disparities in income, and hence the inability of the masses to acquire food or other commodities from distant lands, demands began to grow. Initially, manufacturing was probably centered around the basic needs of food, shelter, and clothing. For instance, food processing implied salting, drying, and pickling, with simpler ingredients than the manufactured foods of today, with the order of magnitude increases in the varieties.

Staying in the same era, life was not much different in the wider world beyond the tropical islands that were considered above. In terms of food, the basic necessity, the essential characteristics were the same even though the differences in the climate and the natural environment offered different opportunities and posed challenges different from that faced by the tropical islanders. Specific commodities used as food were different, reflecting what was plentifully available or could be grown in the native habitat. Growing seasons might have been shorter, but food could be stored for longer period, possibly making greater use of the information systems for trade and otherwise sharing information.

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Biographical Sketch

T. Govindaraj, received his Ph.D. (1979) in mechanical engineering from the University of Illinois at Urbana-Champaign, and a Master of Science (1977) degree in aeronautics and astronautics from MIT. He also has a bachelor's degree (1971) and a master's degree (1973) in aeronautical engineering from the Indian Institute of Technology, Madras, India. During the spring and summer of 1974, he was a graduate student at the Department of Engineering and Applied Science at Yale University. Since July 1982, he has been on the faculty of the School of Industrial and Systems Engineering at the Georgia institute of Technology. Prior to that, he was on the faculty of the School of Industrial Engineering at Purdue University. His primary interests are in understanding and characterizing the role of humans in technologically complex environments, with scope ranging from well-defined engineered systems to globally distributed systems in which cultural, environmental, political, and social factors are significant.