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Superdistribution: An Electronic Infrastructure for the Economy of the Future

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Superdistribution is an approach to distributing digital information, in which digital information in all its varieties, including but not limited to computer software and databases, is distributed in a protected form and is freely available at little or no cost. Furthermore, the information can be redistributed without restriction, and superdistribution ensure that information publishers are paid for the use of their products. In 1995, some companies announced plans to open new business based on the superdistribution model. This paper explains the fundamental concepts of superdistribution and discusses the fact that the structure society has evolved for the distribution of tangible goods is inadequate for the distribution of digital information. The paper also describes how superdistribution can bring about the effective and economically rational distribution of digital information and can promote the production of software, both in the form of components and in the form of integrated products. In this paper we describe how superdistribution will provide the electronic infrastructure for this forthcoming economic revolution. The paper refines and extends our previous paper on this subject, published in Japanese, which received an IPSJ SIG Research Award.

1. Superdistribution

1.1 What is Superdistribution?

"Superdistribution [1)~3)]" is a technology and a system of economic, contractual, and social arrangements for supplying and distributing digital information. Its essential properties are these:

(1) Digital information in all its varieties, including but not limited to computer software and databases, is distributed electronically in a protected form and is freely available at little or no cost. Information publishers charge only for the service of making the information available and not for the information itself, much as a publisher of a printed version of Shakespeare's works would charge for the paper, printing, and binding without paying royalties to Shakespeare's heirs. The distributed information itself is inherently free. Furthermore, the information can be redistributed without restriction, just as a publisher can legally copy the words out of one Shakespeare edition to create another one. Current designs call for using encryption to protect distributed information against piracy, but other forms of defense are now being looked into.

(2) Each information user has a computer equipped with a Superdistribution Label Reader (SDLR). The SDLR, which can be implemented either as an attached hardware device or as a monitoring program, unscrambles the protected information and tracks its usage.

(3) An author receives income in the form of usage fees. We use the word "author" in its broadest sense to mean any individual, corporation, or other organization that originates digital information. The usage data accumulated by the SDLR is periodically collected by a collection agency, which then bills the user (most likely by charging the cost to the user's credit card) and credits the author's account. Alternatively, the user will be able to pay in "digital cash" when that technology becomes available.

(4) Authors may set the fees and conditions for using the information they provide. The SDLR ensures that the fees are collected and that the terms and conditions of use are enforced. The protection ensures that whenever information is used, the usage is tracked by the SDLR.

(5) The usage of an information product can be tracked even when the product is accessed through a hyperlink such as software components and multimedia data.

(6) Information products obtained via su-

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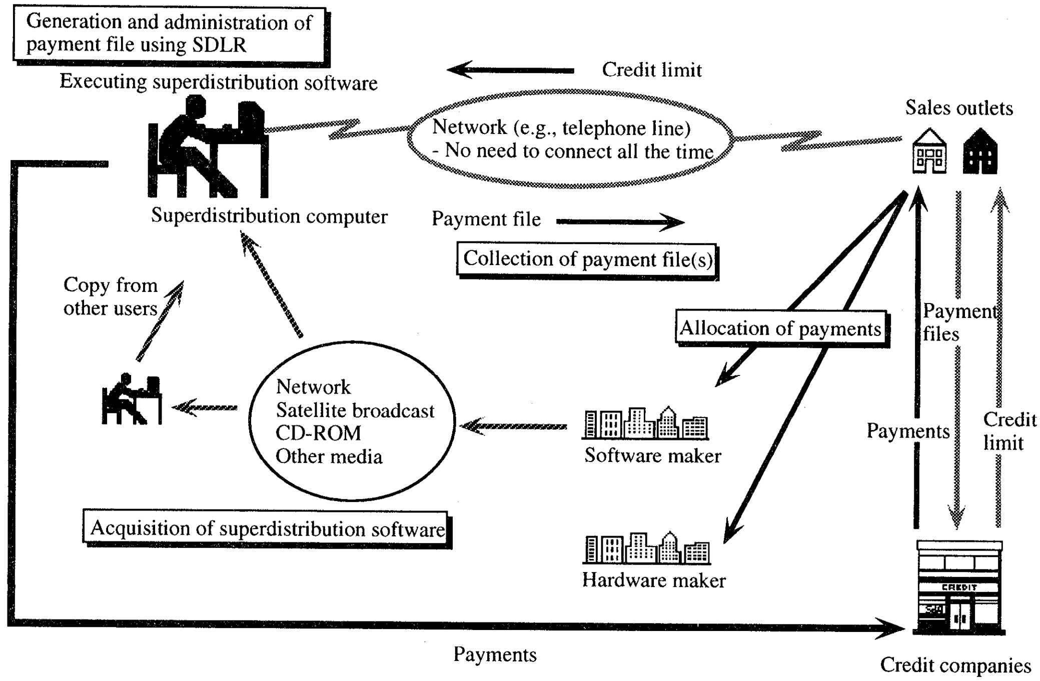

Fig. 1 Example of superdistribution system.

perdistribution are protected from modifications not authorized by their authors.

(7) Overhead costs of the superdistribution system are minimal. In particular, authors pay nothing for distribution and only a tiny amount for fee collection.

(8) Information can be distributed by broadcast, CD-ROM, network communication, or any other convenient medium.

Superdistribution promises to revolutionize the economics of information production, distribution, and use by making immense quantities of high-quality information available at minimal cost. Although the superdistribution technology applies so far only to digital information, we are investigating the possibility of extending it to analog information as well.

An example of a superdistribution system is shown in **Fig. 1**. The SDLR (Superdistribution Label Reader) is installed in a computer. When a program is executed, the SDLR verifies that the terms and conditions attached to the program have been satisfied, and records an appropriate entry in a payment file. When the payment file is eventually transmitted to a collection agency, the program's author is credited with the usage fee. Other forms of digital information are handled similarly.

The superdistribution architecture prescribes logical specifications for implementing superdistribution. The two major components of these specifications are

(1) the enforcement of the terms and conditions attached to an information product

and

(2) the collection and processing of usage records.

1.2 The Superdistribution Label

Superdistribution can be defined in terms of its elements as well as in terms of its functions. The two principal conceptual elements of superdistribution are these:

(1) Electronically attaching identification together with terms and conditions of use to a digital information product. The identification and the product itself can be in different files as long as they can be unambiguously connected. That arrangement could be useful for information products distributed over the Internet.

(2) Electronically collecting and processing the record of charges incurred for using that product.

The identification in (1) is called the "Superdistribution Label" (SDL). It must at least have the following two properties:

- It must be protected from improper modification of any kind.

- Its form must be compatible with data structures already in use and with media such as CD-ROM, MD, and DCC.

The main purpose of the SDL is to ensure that the user of a product and its author agree on the terms and conditions of the product's use. Since the payment due is computed according to the data in the label, there can be no misunderstanding as to what the terms and conditions are, and in particular what the cost of using the product is.

Some, but not necessarily all, of the information in the label is visible to the user. For instance, the user needs to know the cost of the product but not how the charges for the product are distributed among sublicensees who have provided portions of the product.

The SDL also includes identifying information such as the name of the product, the name and identification code of the authors, and possibly a brief description of the product. The identification code ensures that the author is properly credited for usage of the product.

When one information product makes use of another, for example via a hyperlink, the superdistribution label of the first product can automatically incorporate the superdistribution label of the second in order to preserve the rights of the vendor of the second product.

Alternatively, the hyperlink can merely provide an access path from the first product to the second. In this case the second product is treated by the SDLR as an independent product, and its usage records are created just as though it had been accessed independently.

1.3 The Economics of Superdistribution

The cost of selling a product has two parts: fixed costs and incremental (per-unit) costs. The incremental costs consist of the costs of getting the product to its users and of receiving payment. Easy distribution nearly eliminates the cost of getting the product to users and the SDLR nearly eliminates the cost of receiving payment, so superdistribution drives the incremental cost of a product almost to zero.

Superdistribution does not affect the fixed costs of a product, such as program development. But by increasing the number of units sold, superdistribution does reduce the fixed cost per unit. The two reductions working together are what makes superdistribution such a powerful idea.

2. History of Superdistribution

2.1 The Birth of Superdistribution

The concept of "superdistribution" was invented in 1983 by Ryoichi Mori, then at the University of Tsukuba. He first called it the Software Service System (SSS) in analogy to "Water Service System". Few people then appreciated the necessity of an electronic technology for the distribution of digital information, so this name was more appropriate at the time than "superdistribution", a name that sounds more revolutionary.

Mori and Tashiro listed nine terms and conditions that the Software Service System had to satisfy[1]:

(1) It must be secure against tampering.

(2) A user must be permitted to copy the software freely, store it anywhere, and execute it at any time.

(3) The system must not be tied to particular hardware or types of media. It must treat the software as pure information. Low-cost distribution based on electronic transmission methods must be possible.

(4) A user must be able to try out software at little or no cost and have the option of returning the software if unsatisfactory.

(5) The system must provide a variety of methods for granting permission to use a software product. In particular, a user should be able to use the software anonymously as long as he or she pays the usage fee, or a software vendor should be able to limit use of the software to a specified list of users.

(6) The security of the system must not be dependent on concealing its structure.

(7) New vendors should be able to join the distribution system easily.

(8) The system must include a mechanism for marketing software components as well as entire software products.

(9) The system must be acceptable both to those who use it and to society at large.

In 1987 the Japan Electronics Industry Development Association formed the "Microcomputer Software Basic Technology Specialization Committee", generally known as the "SSS Committee" and later renamed the "Superdistribution Committee". In February 1988 this committee published a report entitled "Software Distribution Problems and Countermeasures"[4]. In the preface of that report, the term

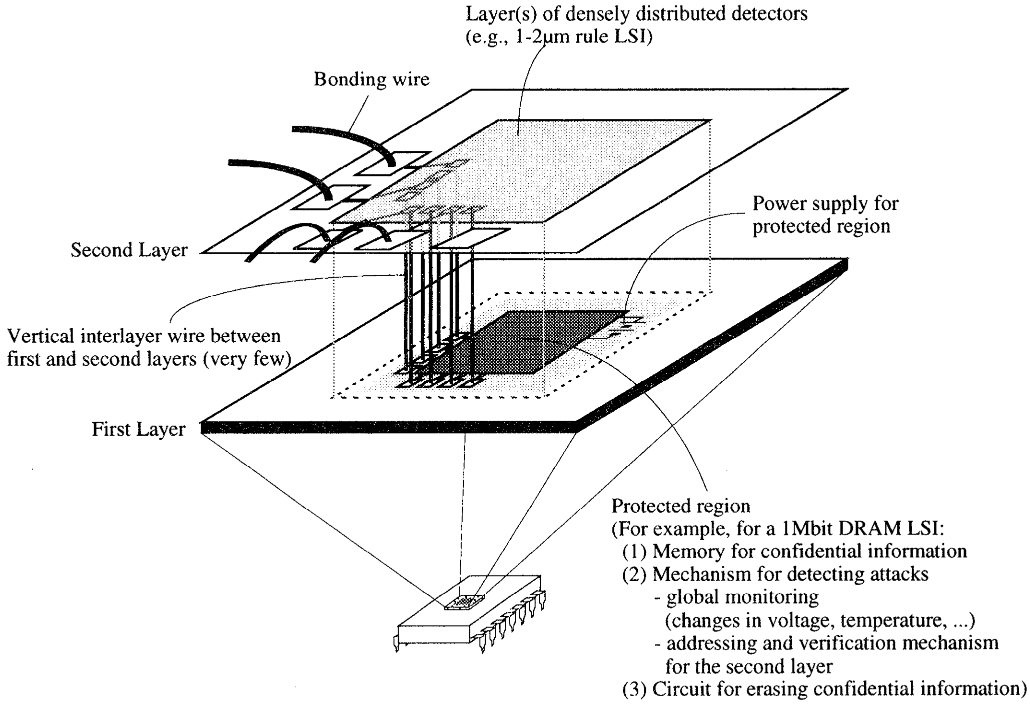

Fig. 2 Example of three-dimentional IC implementation of hyper security integrated circuit.

"superdistribution" was used to describe a system that would bring about a "super market" and "super reliability". That report is believed to be the first place the term "superdistribution" appeared in print, though it had been used during earlier committee discussions.

2.2 The Evolution of Superdistribution

In 1986 Prototype I for superdistribution was developed[5]. This prototype consisted of a Software Usage Monitor (SUM) administering a payment file by means of a connection to the serial port of an existing computer. Construction of the prototype verified the feasibility of the superdistribution scheme even though the serial port connection did introduce some overhead. The term SUM was later replaced by the term SDLR, which we have already described.

In 1988 Hyper Security Integrated Circuit (HS IC), designed to be mounted on a three-dimensional IC (**Fig. 2**), was invented[6]. A Hyper Security IC is an electronic device with both storage and processing capabilities, physically packaged so its contents cannot be examined except through its designed interface and logically protected by an encryption mechanism. Even the people who design and manufacture the Hyper Security IC cannot access its contents in an unauthorized manner. HS ICs play a critical role in superdistribution and have many other applications as well. However, not all currently contemplated implementations of superdistribution make use of HS ICs.

In 1989 Prototype II, a more practical superdistribution module, was developed[7]. Prototype II utilized the coprocessor interface of an existing computer to implement an SDLR. It had the following features:

- Its overhead was acceptably small.
- The module could be used with multitasking computers.
- It could be implemented either as a single chip or as a subsystem of a CPU chip and therefore could be manufactured and installed cheaply.

The new analysis also revealed that different forms of charging, forms that would not be possible for sales of tangible goods, would be possible for the superdistribution of digital information[8]. Among the forms that appeared feasible were trial-usage charging, meter rate charging, automatic purchase, refund after purchase, special licensing, and usage free of charge but with an obligation to report the usage.

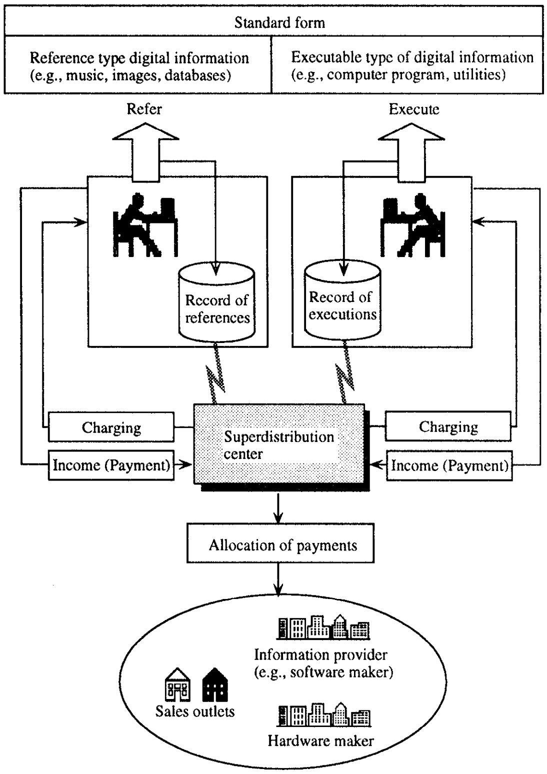

Fig. 3 Example of superdistribution system (modified version of Yoshioka's figure[10]).

By 1990 concrete studies on handling digital information other than computer programs had also begun and a superdistribution system for digital audio had been designed[9]. Researchers are now considering the application of superdistribution to two types of digital information: executable information, primarily computer programs, and reference information, primarily music, images and databases. An example of a superdistribution system illustrating the two types of digital information is shown in **Fig. 3**.

Current research is looking at possible designs of the payment system for information products that are connected through hyperlinks, such as a software object and multimedia data related to that object[11].

3. Why Superdistribution Has Not Yet Been Realized

3.1 The Microcomputer Revolution and Software

The microprocessor was born in the early 1970's. Its capabilities and sales have grown rapidly since then and assuredly will continue to do so in the future. The advent of the microprocessor made possible the mass production of computer hardware. Though a microprocessor processes digital information, it is itself a tangible product. Unlike digital information, therefore, microprocessors require neither a special distribution system nor special legal treatment of their distribution.

Digital information differs from digital hardware in that copies of the same quality as the original may be made rapidly and inexpensively. That property, which at first seems to be an unalloyed advantage, turns out to imply difficult questions about ownership, reflected in the uncertain state of intellectual property law. Another important difference is that it is normal to produce millions of microprocessors of a single type, while computer programs cannot be mass-produced even though they can be mass-replicated. A further difference is that the production of computer hardware is supported by a component industry, but there is no corresponding component industry for computer software.

3.2 The Aim of Software Researchers

Few software researchers are interested in practical questions. For example, spreadsheet programs are enormously popular and used by many people, yet little is said about them at academic meetings. Researchers pay too little attention to the most important contribution that software has made to society: the improved flexibility and reduced unit cost of digital information.

Achieving low pricing through mass production is an important goal of the microprocessor industry. For software the effect of mass production is even more pronounced than for hardware (the unit price can be halved by selling double the quantity), yet there has hardly been any research on how to increase the demand for software or how to produce dramatic gains in its flexibility and price. People find it hard to believe that major advances in software production are just around the corner. In the following section we show how superdistribution can bring about such advances.

Some people might argue that object oriented programming already addresses the question of a component industry for software. However, Brad Cox, a leading proponent of Object Oriented Programming, sees superdistribution as a more revolutionary approach. In one of his articles[12], Cox said that "whereas the PC revolution isolates individuals inside a stand-alone PC, superdistribution establishes a cooperative/competitive community around an information-age market economy."

4. Historical Inevitability of Superdistribution

4.1 Evolution of the Monetary Economy

An effectively functioning distribution system is indispensable to a functioning society. Thousands of years ago, when a man wanted his neighbor's property, the only way he could get it was by force. The recognition of barter as a means of property exchange was the early part of the first economic revolution.

The later part of the first economic revolution was the development of a monetary economy for tangible goods and for services. Money provides a medium of exchange; and unlike many tangible goods, it does not decay. The development of a monetary economy meant that when someone wanted, say, a horse, he did not have to possess an object that some horse-owner would take in trade. It was sufficient to sell his own property to anyone at all for money and use the money to purchase the horse from its owner.

The monetary economy has evolved in very sophisticated and often unrecognized directions since those early primitive days, and society has many subtle structures and conventions that arise from our monetary economy.

4.2 Digital Information As an Industrial Product

Digital information has become an important industrial product, with properties quite different from those of tangible goods. These are some obvious examples of the differences:

(1) If the owner of a tangible item (e.g., a plot of land, an automobile, a sack of potatoes, a microprocessor) transfers that item to another party, the owner necessarily no longer has possession of that item. Only one person can own it at a time. But if the owner of digital information gives a copy to someone else, the owner still has the information.

(2) Mass-producing tangible goods on a worldwide scale can create problems of resource depletion and waste disposal. Digital information per se does not suffer from those problems, though the media on which they are recorded may suffer from them.

(3) Most tangible goods require an energy source. The possibilities for economy in energy consumption are very limited, as they are for the fuel consumption of automobiles. However, for digital information there is a lot of room for theoretical improvement before we reach the constraints implied by Planck's constant.

The effects of tangibility are pervasive in our society and in our individual lives. Here are some examples:

(1) Coffee and tea must be sold in separate cans; the two products can't be mixed together. Such separation is not necessary for digital information; many types of information can be packaged as a unit.

(2) Electricity, gas and water are delivered to our homes via separate conduits; different kinds of digital information need not be. Indeed, with digital information, it is natural to use just a single conduit, even though current practice is to use different channels (telephone lines, cable television lines, high-frequency broadcast) for different types of information. A single channel does, however, require an index or other locator in order to sort out the different kinds of information passed through the channel. Utilities such as electricity, water, and gas require no such index.

(3) We protect our money by placing it in a wallet. Though the wallet provides little physical protection, we don't all carry portable bank vaults with us since our money is still protected by the law. This form of protection works because both the wallet and its contents are tangible; if the wallet is stolen, the fact that it is stolen is manifest. Digital information is different. If it is stolen, we may not know it; and even if we know it, the law may not help us redress the loss.

(4) When manufacturing supplies arrive at a factory they are often subjected to acceptance testing to make sure that they meet their specifications. But not all tangible goods are subject to such testing; when purchasing oranges, we assume without testing that we will not get sardines. Digital information is more difficult to identify than are tangible goods, yet acceptance testing is rarely performed on dig-

ital information when it is purchased.

These examples help to show the important role played by the "distribution label" described in Section 1.2.

4.3 The Second Economic Revolution

It may at first appear that digital information is very difficult to work with. Indeed, the "software crisis" might be cited as evidence of that. But that view is fundamentally mistaken. It has taken us millenia to evolve an acceptable structure for the distribution of tangible goods through the monetary economy. It is not reasonable to expect a similar structure for digital information to evolve overnight.

Clearly the structure society has evolved for the distribution of tangible goods is inadequate for the distribution of digital information. Nevertheless, people seek the easy path to the distribution of digital information by redesigning the existing system even though that kind of redesign is unlikely ever to work. It is possible to cross a small river in a rowboat, but a rowboat won't do for crossing the ocean. If we try to master the shift from tangible goods to digital information with a "digital rowboat", almost surely we shall sink.

Digital information, both as an industrial product and as an asset, has a great many valuable properties not possessed by tangible goods, but our present society disregards those benefits. The reason is simple: because those benefits are unfamiliar, people have had no opportunity to enjoy them and hence do not yet appreciate them.

An important property of digital information we mentioned earlier is that if someone shares it with another, the value of the information is undiminished. History tells us that bloodshed has been caused more than anything else by a struggle for wealth. When digital information becomes a major industrial product, society may at last find the means to put an end to the long saga of human poverty and bloodshed.

But digital information has unique problems of its own. When a piece of digital information is distributed to others without any precautions or constraints, those who receive it gain its benefits without having exerted an effort comparable to that of those who created it. Ensuring that the creators of digital information reap the fruits of their efforts is the most difficult and central problem confronting the information-driven society of the future. But that is a problem that we believe can be solved with the technology of superdistribution, leading to the second major economic revolution in the history of mankind.

5. Concluding Remarks

The earlier part of the first economic revolution was the transition from a pre-barter economy to a barter economy. The later part of the first economic revolution was the transition from a barter economy to a monetary economy for a world of tangible goods. In this paper we have described how we could foresee a second economic revolution, the transition to a world of digital information. Superdistribution will provide the electronic infrastructure for this revolution.

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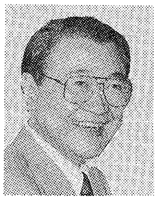

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