New Challenges of Package-Based Communication

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Abstract: The original function of packaging was to protect the product. Today, however, packages have to meet increasingly rigorous requirements. This is especially true of consumer packaging, where one of the main purposes of the package is to market and sell the product. Because of this, packaging is nowadays an integral part of the trademark. Moreover, due to the requirements of the authorities and consumers, packages need to contain precise product and safety information. In the future, packages will become an increasingly important medium of communication. Manufacturers will also want to trace their products more accurately and pack shorter series (or smaller quantities) for different user groups, language areas, etc. The number of packages will increase in information societies. Future packages will thus be much more multifunctional, informative and demand-driven than they at present. This is why packaging industry companies are interested in all R&D activities that pave the way for future ways of doing business.

VTT Information Technology has launched a project to develop a comprehensive system for new kinds of package production chain. The system pays attention to the special needs of consumer packages with regard to product information, identification and appearance. Our project is being carried out under a larger VTT-driven theme, the main purpose of which is to develop and integrate Active, Communicative Packaging with an effective logistical system for sensitive, demanding products. Intelligent coding, RFID and data networks are the technologies applied. In this paper we present different aspects of our packaging research regarding the communication needs of consumer packages and especially the utilisation and potential of digital printing.

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Intelligent Products and Systems

Four VTT-wide themes were launched at the beginning of 2002, one of which is Intelligent Products and Systems. The Intelligent Products and Systems theme aims to make synergetic use of new technologies to develop intelligent products and systems which can be applied in future societal and business concepts. Intelligent products capable of observing, processing information, reacting and communicating will be able to adjust to different circumstances and communicate with their environment.

From a holistic perspective, intelligent products/systems have the following features:

- They continuously monitor or perceive their status and environment (awareness)
- They react and adapt to environmental and operational conditions
- They maintain optimal performance in varying circumstances, also in unexpected cases
- They actively communicate with the user, the environment or other products and systems
- Many of these properties result from long evolution in living organisms => in the future, machines will imitate nature (biomimetics) and will be smart or intelligent
- A “smart” system adapts to expected situations in a predictable manner. An “intelligent” system is able adapt to unexpected situations as well (reasoning and learning)

Active, Communicating Packaging

One of the projects in the above mentioned Intelligent theme is Active, Communicative Packaging. Figure 1 shows the principle by which the multidisciplinary knowledge of our organisation is combined to achieve innovations that will lead to applications that ultimately serve consumers.

The purpose is to develop packages that will give the product the required protection without additives. They will deliver information about the product (its condition and history in every phase of the logistical chain) and control the progress of packages, thus decreasing losses and mistakes. Packages will communicate topical information about the characteristics, usage and state of the product to consumers and consignees in entertaining ways. The idea is to increase the efficiency of the logistical chain while decreasing the use of packaging materials and packaging waste. The goals are to create intelligent packages in intelligent logistical chains, to integrate intelligent components into intelligent packaging systems and to develop intelligent components for consumer and industrial applications.

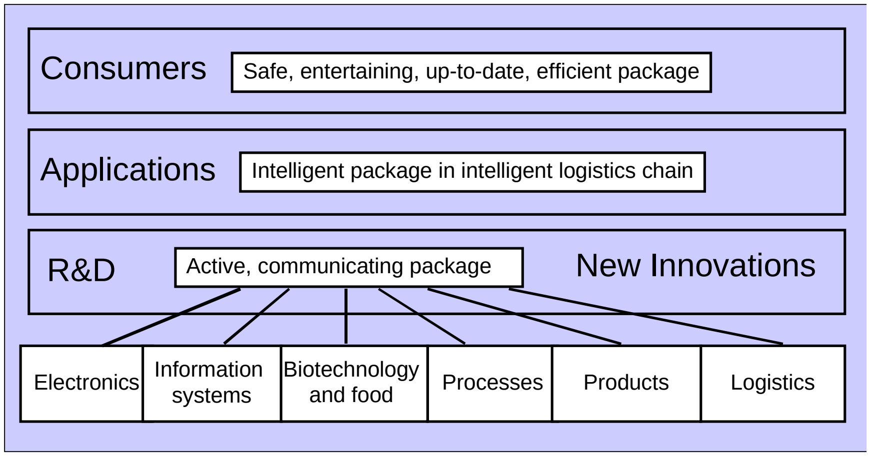

Figure 1. Active, communicative packaging - from research to finished products.

Target - intelligent packaging in an intelligent logistical system

The main goal is to develop a comprehensive, effective logistical system for sensitive, demanding products. The system is based on active, communicative packaging and mobile communications.

New functional characteristics can be created for customer packages in order to create value-added in the package itself (advertising, consumer information and education; edutainment, infotainment, etc.). Value-added can also be created for the packed product (prevention of damage, freshness) or to produce savings for consumers (less waste, no overpacking) and/or suppliers (traceability, theft protection, optimisation of the supply chain).

So far the focus has been on four subareas (see Figure 2), which interact with each other. These areas are:

1. Communication in consumer packages
2. Measuring systems
3. Logistical chain
4. Manufacturing technologies

Next, we will describe some of the challenges of digital packaging production and our research approaches in these areas.

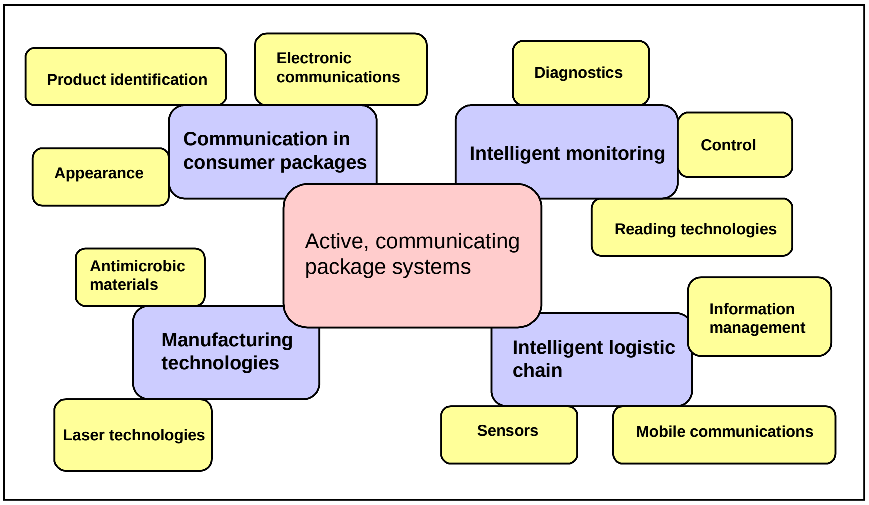

Figure 2. Technology map of Active, Communicative Packaging Systems.

Challenges of new requirements for package production

The general trends in packaging production, such as shorter delivery times, larger selections and smaller product quantities, give an impetus to develop package production and packaging logistics. It is also important to develop packages so that they have better product information, a more visible trademark and a more selling appearance. More precise product specifications and better product traceability are today required by consumers and the authorities. There is the tempting possibility to use consumer packages as a medium for advertisements. One tool to boost package communication is on-demand package production, in which the production of packaging or the whole product does not start until the order has been received. This brings extreme flexibility to the package production chain. The benefits of on-demand package production are that it:

- allows the production of customised and tailored packages
- means shorter delivery times, which helps to improve customer service
- decreases the waste of materials, which saves costs and nature
- decreases storage costs
- shortens production chains and accelerates production, which saves costs
- allows the production of packaging or even products to be started after order
- allows totally new kinds of products and business opportunities to be implemented

The key technology for flexible package production is digital printing. Because digital printing is masterless, i.e. there is no plate or cylinder that needs to be prepared in advance, it can produce small quantities of printed products cheaper and faster than any other printing method. Digital printing plays an important role in developing new operational and business models, because it provides a strong tool for the value addition of packages. Moreover, by using digital printing methods, different work phases can be integrated, and the transportation and storage of semi-finished products can be avoided. Printing can also be decentralised and done in the locations where it is logistically most economical. In short, the main benefit of digital printing is that it opens up possibilities for new ways of marketing and creates logistical savings. VTT Information technology has started several multidisciplinary projects to screen the possibilities and technical solutions of new digital package production chains.

Challenges of utilising digital printing in package production

There are two main utilisation areas, dictated by the present level of digital printing technology, in which variable information printing on packages can be implemented. In the first case, the whole package is printed digitally, so that every printed package can be 100 % different. In this case, the production speed is limited by the speed of the digital printing press and the degree of variability, which depends on the performance of variable data printing (VDP) software and raster image processor (RIP) hardware. The workflow of this case can be seen in Figure 3.

Four-colour digital printing is usually done by electrophotographic means, but nowadays high-speed ink jet printers can also be used. During recent years, ink-jet printing technology in particular has developed rapidly and new applications have been created to produce documents, publications, personalised advertisements, security documents, textiles, cartons and packages. The method is suitable for a wide variety of materials, frequently updated information and for multicolour high-quality products.

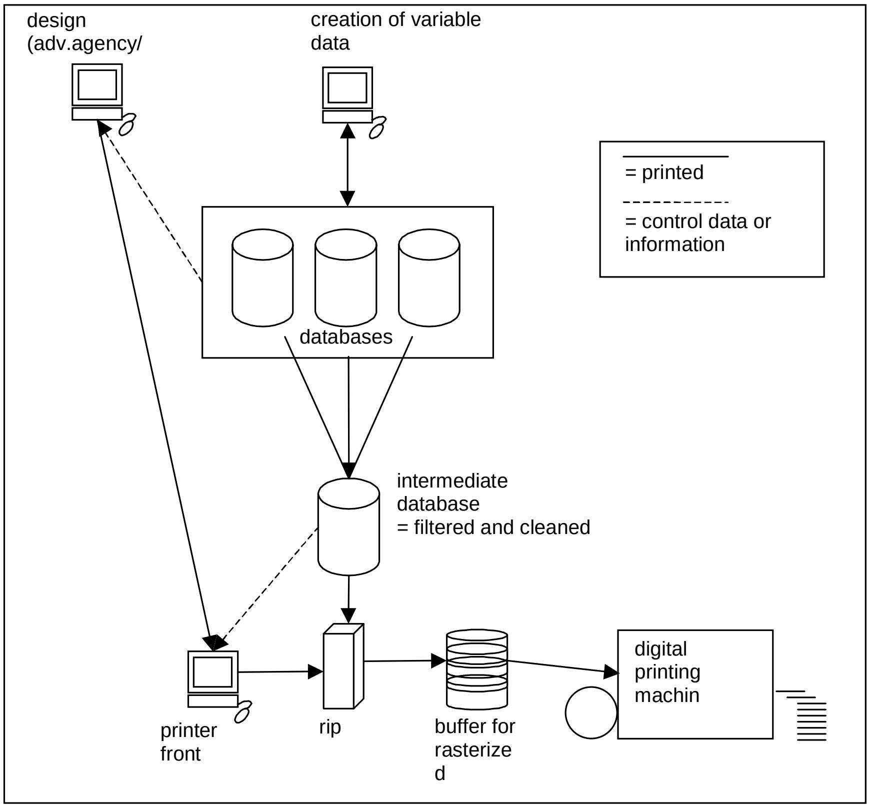

Figure 3. Workflow of digital printing of packages.

Another way to utilise digital printing in packaging production is to use ink jets to add variable information onto pre-printed packages, which are often printed by conventional printing methods. This workflow is shown in Figure 4. Typically only black or one spot colour is added. The flexibility of ink jet technology makes it possible to place ink jet heads at the right location in the printing or packaging process. For example, the heads can be placed in the conventional printing press after traditional printing or they can be integrated in a packaging line before or after packaging. In any case, each interface and procedure must be carefully pre-organised so that the actual work flow will go smoothly.

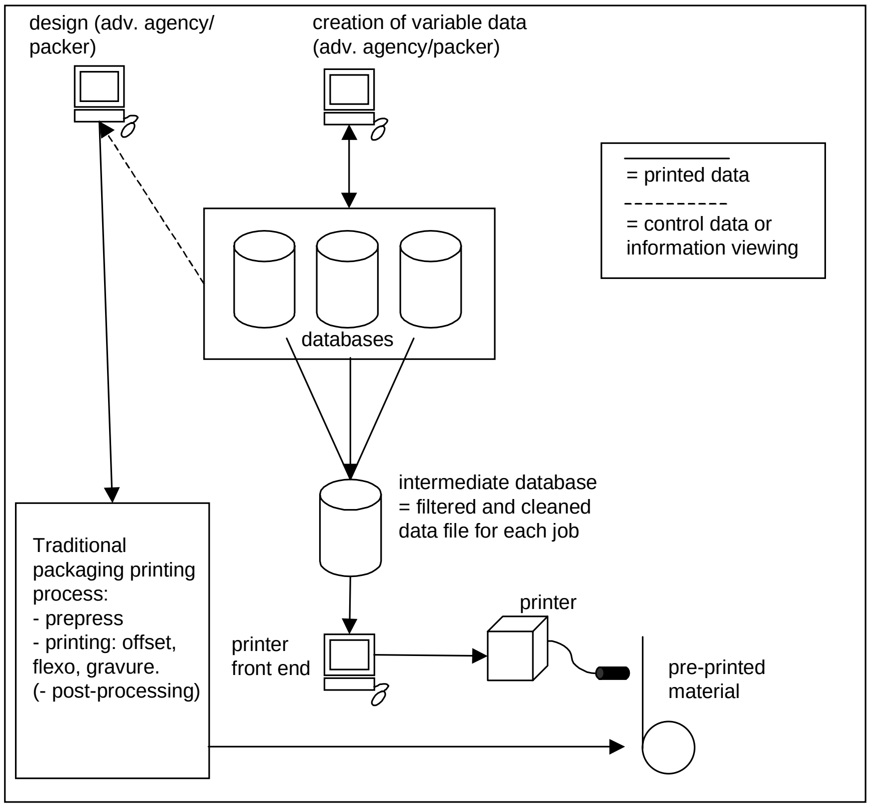

Figure 4. Workflow of digital printing for pre-printed packages.

In digital package production, it is important to understand that digital printing does not eliminate the need for graphic reproduction. In fact, variable data printing (VDP) adds complexity to an already complex process. The digital job must also be adjusted according to the target printer, so we still need to take care of reproduction of details, colour management, the right content of text, etc. In the digital workflow, these tasks are easier and quicker to accomplish, because many of them can be automated or semi-automated.

One bottleneck in the digital package process is converting. Many converting stages are needed for packages after printing, such as scoring, die-cutting, varnishing, folding, gluing and filling. These stages should be integrated as an inseparable part of the digital work flow to avoid expensive manual work and to gain the greatest benefits from digital package production. Because the digital manufacture of packages is a new concept, there are only a limited number of suitable alternatives for most packaging applications. For this reason, converting machines must often be developed or at least tailored as part of a digital manufacturing line development project. VTT has actively participated in projects to develop digital package production systems.

Challenges of materials in digital package printing

Different demands are placed on materials in electrophotography and ink jet printing. Generally speaking, electrophotography is more material-independent - as long as high quality paper and board grades are used. Problems appear rapidly with uncoated and uncalandered paper grades, because electrically charged dust particles, wood fibers and fillers, will magnetically accumulate inside the digital printing machine. This requires time-consuming and expensive maintenance of the printer. High demands are also set on the curling tendency of paper in electrophotography, because the material undergoes great changes in temperature and humidity. High temperature in the fusing phase will also set high standards for the temperature endurance of the printing material.

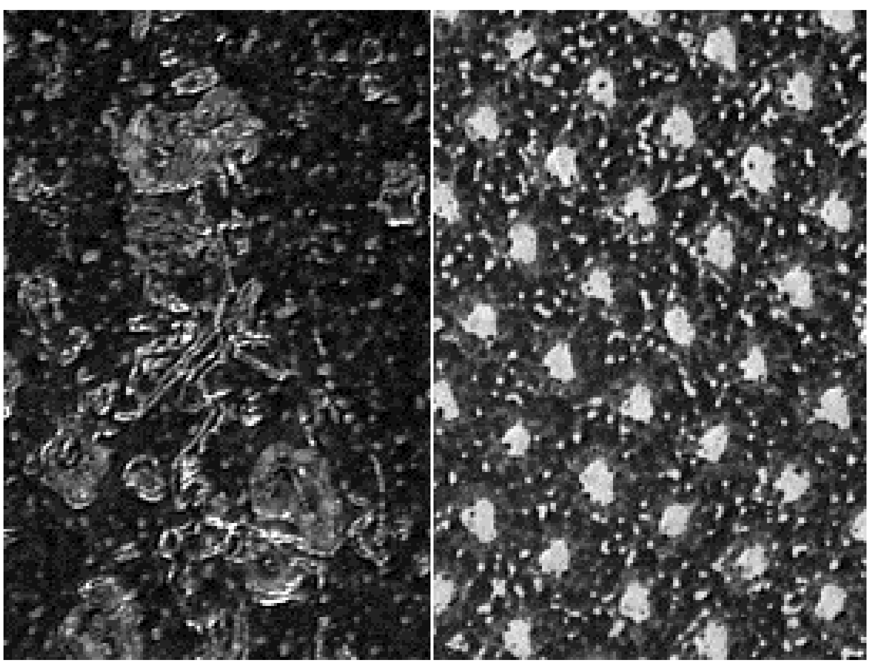

Figure 5. An example of problems arising because of high fusing temperature in the electrophotographic process. Left: Melted surface of polyetylene coated liquid packaging board. Right: Raster field on polyetylene printed with a lower fusing temperature.

One example of problems that can occur in packaging applications can be seen in Figure 5. In this case, the surface of the polyetylene coated liquid packaging board has been totally destroyed, because of the high fusing temperature of the process. When the fusing temperature is lowered, the raster field can be printed. The downside of this approach is that the printed surface, if standard toners are used, will be lusterless and the appearance of the final package will be dull. VTT Information technology has many years of experience with regard to material questions in electrophotography.

Ink jet printing sets even stricter demands on the printing material, because the image is created directly onto the surface of paper, usually using solvent-based inks. The print quality will decrease dramatically, if ink flows on the surface of coated paper, as can be seen in Figure 6, or spreads in the capillary network of uncoated paper.

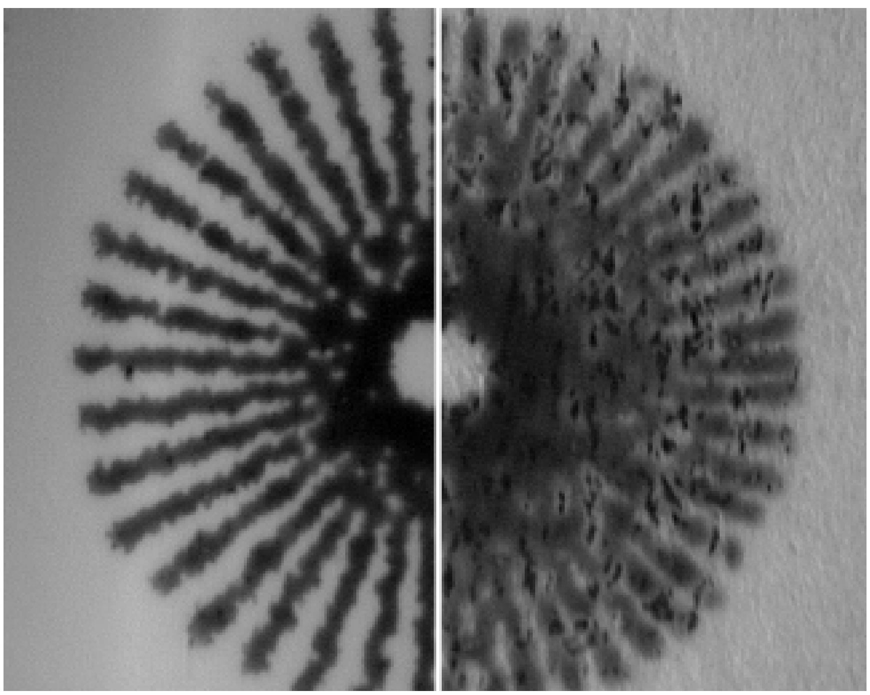

Figure 6. Detail rendering test pattern on two different coated papers printed by the same printer. The print quality in ink jet printing is extremely surface-dependent.

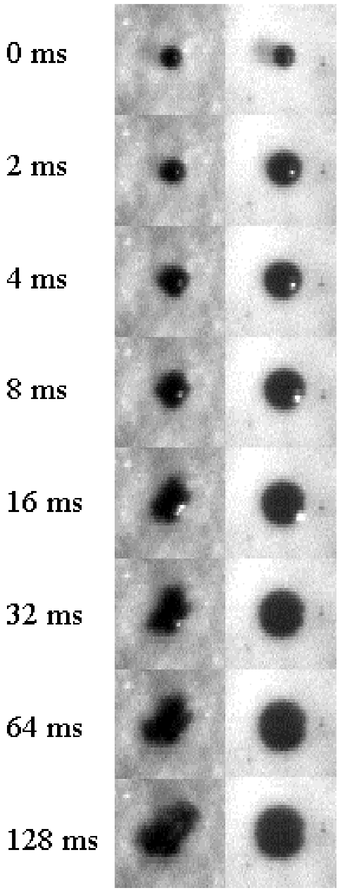

Figure 7. The behaviour of 3 pl ink drops on two different papers during the first 120 ms after impact.

These phenomena are especially crucial in high-speed ink jet printing where there is no time for evaporation of solvent. A better knowledge of the basic mechanisms of the dynamic interaction between ink and paper is needed to produce more reliable and appropriate quality specifications for printing surfaces. A unique approach to this problem is the laboratory-scale testing environment developed by VTT Information Technology for the high-speed imaging of ink jet drops. The impact, spreading, absorption and drying of the ink droplets on the samples can be observed and analysed in this testing environment on a time scale of milliseconds up to several minutes. Differences in spreading dynamics between paper grades can be noticed immediately after drop impact, as can be seen in Figure 7. In the absence of any other method to detect these high-speed phenomena, this research environment has proven to be a precise tool for the development of ink jet printing materials, inks and printers.

To sum up, digital printing packaging applications require great care to find the right balance between the printing method, the material properties and the final print quality.

Challenges of improving information and traceability of packages

The most commonly used linear bar code system is the Universal Product Code (UPC) which is one of the most successful standards ever developed. Originally this code was meant to benefit the retail trade, but over the years its use has also become common among raw material producers, manufacturers, wholesalers, distribution companies and consumers. This code makes it possible to control many activities of product supply chains and to track and identify products all over the world. The downside of the UPC bar code is that it carries only a limited amount of information, usually only twelve characters. For this reason, the normal bar code cannot include real information, but it is a link to a data base where the information is stored.

A two dimensional bar code can act as an independent data base. In this case, information can be read wherever a suitable scanning device for the code can be found. The other benefits of two dimensional bar codes are small physical size, scalability, big capacity of data storage and high data density, good correctness of information and high durability. Two dimensional bar codes can be attached to packages by using stickers or printing them straight onto the packages by means of an ink jet printer.

Two dimensional bar codes are usually used in the manufacturing sector, because more information, even over one thousand aphanumerical characters, can be included in the code. Every 2-D code includes an independent data base with total freedom of transportation. This is a great benefit compared to a landline network, because the information can be downloaded wherever the product is. Moreover, special encryption technologies can be used, if the information is confidential. Multi-level confirmation technologies can also be added to the 2-D bar codes to ensure that the code will be read right.

Another developing coding system is Radio Frequence Identification (RFID). This technology allows information loaded onto a tag to be transferred wirelessly and without optical contact between a tagged product and an electronic reader. RFID tags use radio antennas which transmit information over a short range. Active tags include batteries so that they can actively send data over longer distances. Passive tags need power from the reader to be activated and to transmit data. The biggest benefit of electronic tags is that they make continuous identification, tracking and communication of products possible, when they connected to a reader network. Compared to optical bar codes, RFID tags can carry much more information. The downside is that their price is much higher than the price of printed tags, so they cannot yet be used in inexpensive consumer products. In our project, RFID tags are used in expensive products, such as electronics, and in transportation packages.

Conclusions

On one hand, general packaging production trends, such as shorter delivery times, larger selections and smaller product quantities, are setting higher and higher demands on package production and packaging logistics. On the other hand, developing communication and printing technologies are providing new tools for solving problems, boosting production and giving value addition to packages. VTT Information Technology has long-time expertise in this area and several new activities have also been started. One of our projects, called Active Communicative Packaging, is being carried out under a larger VTT-driven theme and its main purpose is to develop and integrate active, communicative packaging with an effective logistics system for sensitive, demanding products. The aim is to develop a comprehensive system for new kinds of package production chain which pays attention to the special needs of consumer packages as regards product information, identification and appearance. The achievements of this project will be reported in the near future.

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