A NOVEL ARCHITECTURE TO FACILITATE DISASSEMBLY AND REUSE OF ELECTRONIC COMPONENTS AND SUB-ASSEMBLIES

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As the volume of end-of-life electronic equipment mounts, and the costs and consequences of landfill disposal escalate, there is increasing interest in the alternatives of reprocessing, recycling and reuse. This paper focuses on some of the important issues relating to reuse and examines a novel approach to construction of electronic products which facilitates disassembly and reuse of sub-assemblies, components and interconnect. Throughout the paper an example of one particular high volume, short life electronic product, the Personal Computer (PC) will be used to provide a practical example of the arguments presented. The designation of end-of-life electronic products as a priority waste stream by the EU means that design for disassembly and reuse of components or subsections of products will become increasingly important.

The ease with which a product can be assembled or disassembled relates to the ways in which the individual components are interconnected into sub-assemblies, and then the means and manner by which the sub-assemblies are mounted and interconnected into the final product. However, this is not to say that products or sub-assemblies which are easy to assemble are also easy to disassemble. The traditional printed circuit board (PCB) provides an excellent example, in that modern automated pick and place equipment coupled to reflow soldering lines make PCBs relatively easy to assemble. However, the process is not as easy to reverse, and disassembly and reuse of components from PCBs has proven to be problematical. Use of adhesives provides another example of a technique where ease of assembly does not translate into ease of disassembly.

There are however approaches to assembly which do translate into ease of disassembly. Socketed componentry, for example, is relatively easy to assemble and to disassemble and in many products particularly valuable or vulnerable components are socketed to facilitate ease of both assembly and disassembly. An interesting point to note here is that not only is the component easy to insert and remove, but also, with imaginative design, the socket remains reusable for a range of uses (e.g. zero insertion force sockets on PC motherboards are often able to take a range of progressively upgradable processor parts).

A number of basic considerations can be noted. There are two central variables - the first is the partitioning scheme which has been adopted for the product and the second is the means and method of interconnection and support used within the product. Conceptually, electronic products are collections of components interconnected into sub-assemblies; in their turn, the sub-assemblies are supported and interconnected within the final product. Disassembly of electronic products results firstly in the separation of sub-assemblies from their means of interconnection and support, and then secondly, in the separation of components from their means of interconnection and support. At the end of a disassembly process there will be a mixture of varying proportions of components, sub-assemblies, and supporting and interconnecting hardware.

If the practical example of the PC is considered, the PC motherboard (printed circuit board) is the means by which one collection of components is supported and interconnected. A number of other sub-assemblies in the form of expansion PCBs implementing particular functions (e.g. graphics cards, disk controller cards, communications cards) are slotted onto the motherboard, by means of a series of edge connectors. The motherboard and expansion cards are then mounted with other sub-assemblies (e.g. disk drives, power supplies, speakers, control knobs) in a supporting metal or plastic enclosure, and various interconnecting wires and harnesses complete the product.

PCs can be relatively easily disassembled into sub-assemblies. The enclosure is taken apart, and the expansion cards, disk drives etc. disconnected and removed. The sub-assemblies, however, are not easily disassembled into components. Only certain high value components (e.g. memory, processor) are socketed and easily removed for reuse. The result of the disassembly process is, therefore, a small number of high value components, a small number of sub-assemblies and a range of interconnecting and supporting hardware (case, connectors, wiring).

Partitioning of electronic products in this way, however, does not contribute in any significant way to the reuse of electronic components or sub-assemblies of electronic products. The reason for this undesirable situation is that the scheme of partitioning, and the interconnection system employed, limit the redeployment of the electronic sub-assembly. For example, an expansion card removed from a PC computer system will often implement a multiplicity of functions. For example, a single card may serve hard disk, floppy disk, parallel and serial communications

design of the memory layer, and should not normally require time-consuming and costly changes to other parts of the system. System expansion is readily achieved, by the simple expedient of adding further layers at top or bottom of the stack, or by temporarily breaking the stack to allow layers to be inserted. Varying production requirements can readily be accommodated in this way.

Test and repair. Test and repair of systems is simplified, since all the carriers have a consistent 'footprint', in common with the assembled system, for ease of attachment to test instruments. Faulty systems are easily dismantled for replacement of defective components.

Reconfigurable bus structure. The pattern of signals passing between each block of electronics can be redefined at the intersection of each circuit block. The ability to reconfigure the bus structure, when coupled to functional partitioning, facilitates the incorporation of new technology into existing products, providing the option of significantly extended product life. Reconfigurability of the bus also means that disassembled carriers can be reused within a wide range of products utilising other bus structures.

Reconfigurable reuseable hardware. Both the major elements of hardware (the connectors and the carriers) are reconfigurable and reuseable . The connectors are not only capable of implementing reconfigurable interconnection between blocks of circuitry, but also provide the means of physical support. The carriers and connectors are both items of general purpose hardware capable of being incorporated or remanufactured into a wide range of alternative products.

Conclusion

This paper has advanced the proposition that in many electronic products, the partitioning scheme adopted and the interconnection system used to interconnect the sub-assemblies or components are intimately related to the economic benefits, and hence the attractiveness, of reuse of these items. An architecture has been developed in which the residual values of the connectors, components and sub-assemblies are maximised, and opportunities for take-back and reuse of redundant items are greatly enhanced. The system described also offers significant manufacturing cost benefits in terms of ease of assembly, compactness and robustness.

References

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