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Subsystem Integration of a Card Protection Device

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Abstract

The documentation of the systems engineering process is itself often overcomplicated and convoluted. The primary means by which this convolution is combated is through a well implemented subsystem integration phase. This research paper will aim to provide an understanding of subsystem integration, particularly in regards to the card safe project positioning as part of a larger system. The card safe project aims to produce a design for a compact card protection device that prevents a person with Obsessive Compulsive Disorder from repeatedly pulling apart smart cards. While due to its simplicity this project does not necessitate an in depth analysis of its own subsystems, it is important to realise where it as a product in its entirety fits within a larger system. This report will explore this wider setting through the demonstration of the Functional Block Diagram (FBD), a method by which project subsystems are classified and modelled, and by which their interactions are defined both internally and externally.

Background Theory

Subsystem integration is particularly important to the systems engineering design process in regards to developing an understanding of the way in which different parts of a system interact at different levels. The impact this has on a system's final design results in a more purposeful and coherent design relevant to any possible interactions with the system. Siemieniuch and Sinclair make a particular reference to the relevance of subsystem integration's reliance on system boundary definition: *'the closer in the boundary is placed, the lesser the number of parameters and variables that have to be considered explicitly but the more likely it is that significant behaviour will be omitted, or simplifying assumptions will be made, that turn out to be errors.'*

The FBD is a core tool to explore these interactions in the most coherent way possible, though can quickly become overcrowded and confusing when implemented without care. The diagram draws on the knowledge of the previously developed systems boundary definition and external factors influencing the system to establish these connections on a more technical and foundational level. This establishment is primarily done for a system on two important and complimentary levels: exploring the system's subcomponents, their relation to each other, and external interfaces to the system as a whole; and taking the system as a whole, and exploring where the external interfaces go in a wider context. The FBD design process has been described as '*A description of a complex system suitable for deriving information necessary for developing a logic model*,' (Papazoglou, 1998) While this reference to a software logic model may seem isolated, it can be drawn out into the general systems engineering process, as Papazoglou continues, *'…[the FBD] should contain information concerning the intended function of the system, the ways and means available to perform this function, and possible constraints.'* The FBD takes the system boundary as an encompassing box and places the subsystems defined in the system boundary chart as blocks within it. Each block is then defined by three elements: inputs, outputs, and internal states. The most commonly found example of an FBD is in the representation of computer systems. Here, it is very easy to define subsystems and their connections, as they are physically represented by components and wires respectively. The US Army and Marine Corps provides an example for a CPU in Figure 1 below.

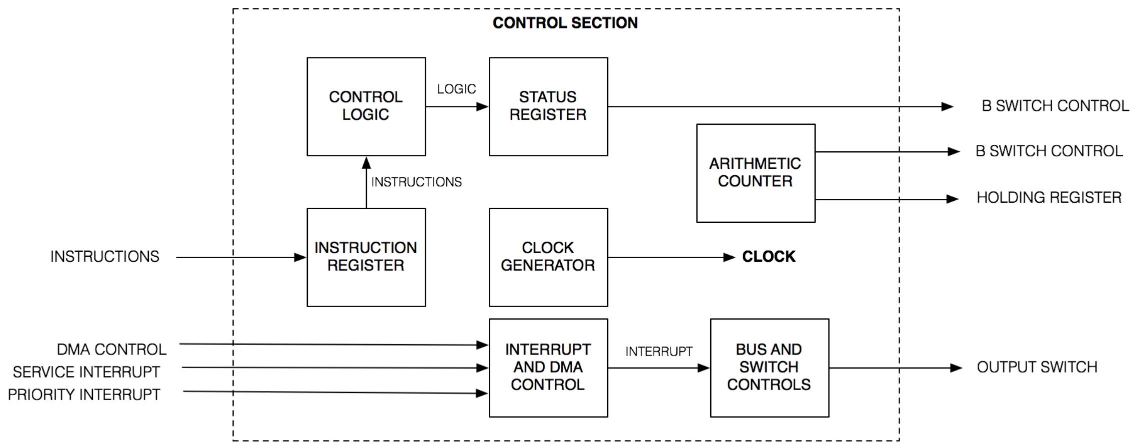

Figure 1: CPU Control Section FBD (USAMC)

More complicated is the wider setting scenario. For this, the system must be put in a wider context, and its purpose defined and critiqued in relation to these surroundings. Figure 2 shows this for the same CPU, while still keeping internal detail.

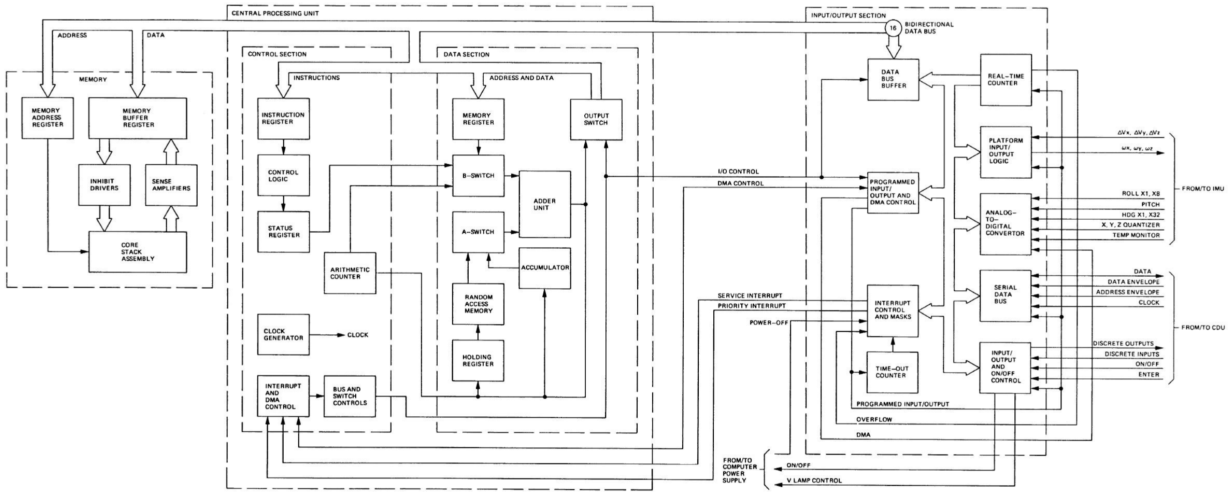

Figure 2: CPU FBD (USAMC) (Expanded version in Appendix

While it is important to note that these two components are merely two layers of a near infinite set of systems, this juxtaposition is of particular importance, allowing the immediate inclusions and exclusions of the system to be closely scrutinised for purposes in relation to the defined system boundary.

As is described by the IEEE in in its IEC standards outline, the creation of an FBD is also an essential one for allowing verification during the verification and evaluation phase. It allows the verifier to see which parts of a system interact and monitor those interactions as necessary, and how each of the subcomponents contributes to fulfilling the customer requirements.

Application

Of specific relevance to this report is the application of the above concepts to a card protection device. The objective of this device is to prevent cards, specifically an ACTION MyWay card, and a Companion ID card, from being disassembled by the user. The user in this case is an adult male with obsessive compulsive disorder, prone to disassembling anything possible. From meetings with a representative of this client, it has been determined that he does this mainly with strong forces from hands and teeth. Accordingly, a hard casing is has been chosen in concept generation to combat this issue. Such a design is of notable simplicity in regards to internal subsystem design and integration, such that it can be represented by the three element FBD below.

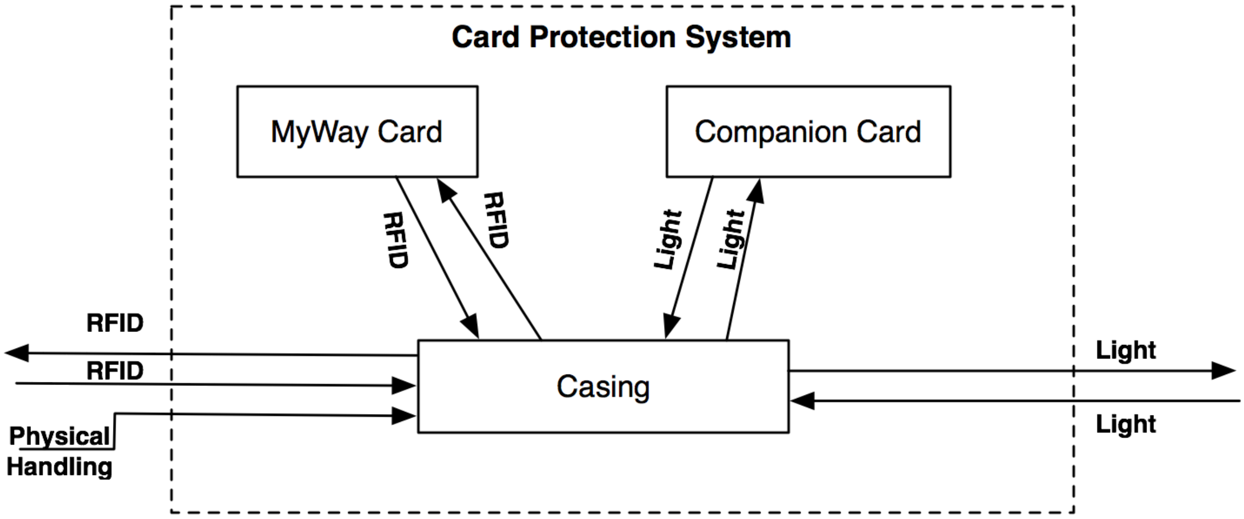

Figure 3: Card System FBD

What can be noted even from this diagram is the inputs and outputs to the system. We can see a requirement for RFID to be transmitted bidirectionally, necessitating the use of materials that allow this, and a requirement for the cards to be visible, necessitating a clear design.

To explore this further, an FBD must be developed for the wider use context. Taking the card protector as a subsystem, applied to the functional flow block diagram previously created for the group project, we can determine the following FBD.

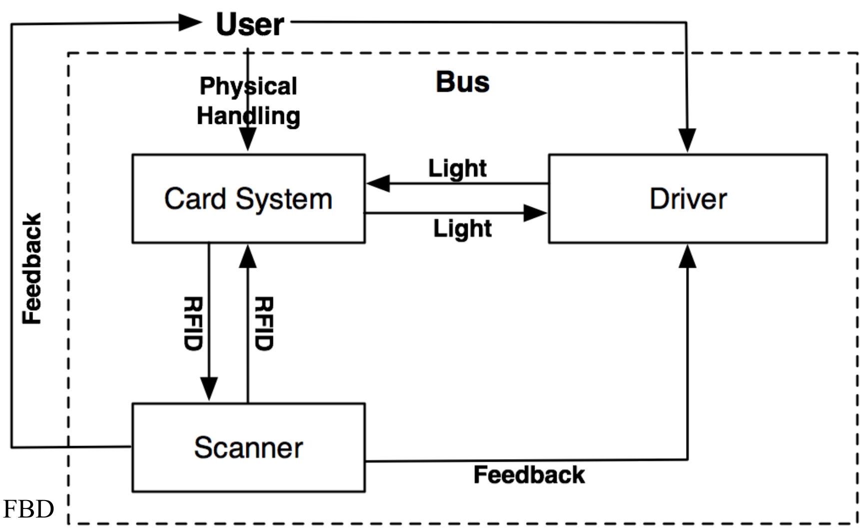

Figure 4: Bus System FBD

This diagram notes the same inputs and outputs to the system, not while showing their purpose in a greater contextual setting. We can see that while the card system is still a simple one, it requires specific interfaces to be working in relation to components external to the system in order to function at any level. These interfaces must be carefully monitored in development.

Discussion

By application of the subsystem integration techniques to the card protection design already conceptualised, we are able to ensure each element of the system continues to fulfil its purpose without being impeded by the design. In doing this, the group has not found any issues with the existing design concept, but has had these concepts reinforced. While we note that this may indicate the process was completed solely on the existing foundlings of the group without thought to new factors, it is believed to be due to the system's simple scope. Careful scrutiny of this process has been undertaken, and will be furthered particularly under the verification and evaluation stage of the design process. This process has vetted and confirmed the proposed design factors that require the card protector to be clear and non metallic, or otherwise permit the transmission of RFID waves from the MyWay card. Visuality is also needed in order to view the Companion ID card by means of physical gaps in the design whilst still keeping the design impenetrable to the user.

Conclusions/Recommendations/Summary

The subsystem integration process is a highly beneficial part of the systems engineering design process, regardless of the project size or scope. The functional block diagram allows for each system element to be contexualised and critiqued accordingly. In addition to this, the definition of subsystems through the FBD allows for progression in the design process to system attributes definition, whereby the subsystem functions are defined further. This in turn, results in a final system in which all system components interface appropriately with each other and external entities.

Bibliography

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Peer Review Critique

The peer reviews for this paper, were unfortunately not as helpful as they could have been. This was, in part, due to directly conflicting advice on a number of aspect criteria. Opposite ends of the spectrum were given, while comments specifically liked and disliked opposite different things within aspects. This resulted in my judgement taking precedence as it would prior to receiving feedback. At other times, the reviewers would misunderstand the topic, or fail to read part of the report, and falsely comment accordingly.

The feedback received from the both peer reviews did, however, give some relevant pieces of feedback in reference to distribution of report content between sections, such that the theory section was too large in proportion to the discussion. While this was good for an ideal report, it did not lend itself to the specific topic at hand, due to the simple nature of the project. This was confirmed with my tutor. Points regarding general formatting were the primary points taken into account.

Overall, the peer reviews each had their individual merits, but did not lend themselves to the specific paper under closer engagement. I would have liked to use their comments more in improving my paper, but could not see a way around the more qualitative issues they presented.

Appendix

Expanded Figure 2