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Hardware Implementation Strategies in Mining & Construction

Rapid changes in mobile computer technologies make it difficult to choose an implementation strategy that serves long term needs. The strategy must address the conflicting goals of cost, capability, expandability, reliability and maintainability. In the end there may well be a tradeoff of these factors. In the current mining market fraught with low metal and coal prices, productivity is king. Increasing capital spending for higher reliability may yield runtime efficiencies that quickly pay for the increased costs.

Typically, current computing systems run software for fleet management, vehicle monitoring, fatigue detection, collision avoidance and many other critical purposes necessary for communications, processing log sensor input, warning drivers of potential hazards and more.

The same basic strategy is used in the vast majority of heavy duty implementations; a dash-mounted display and a CPU with integrated I/O. However, changes in technology and price structuring have inspired other possibilities. Whatever the method, the risk of downtime is a powerful consideration and is crucial to understanding the total cost of ownership.

The first alternative, often called the ruggedized “tablet” approach, perhaps has the lowest initial equipment cost. It involves a display with an integral CPU and set of I/O connectors. It is typically mounted on the dash with all the I/O and power cables somehow channeled to mate with the tablet. Some implementations include high-density connectors and require custom cables to split the I/O out to different parts of the vehicle. Others have smaller connectors with more custom cables.

Other than ruggedization, the tablets are similar to consumer products in that they have a display with a backlight and a separate CPU board with the specific I/O. Considerable heat is generated by the display backlight and the CPU. Since the units are fanless, heavy heat sinks must be provided to prevent overheating. Even so, the displays are mounted on the dashes and can be used in sustained direct sunlight. This solar loading can cause the CPU chip to suddenly reduce speed to protect itself. The software on the system must be immune or aware of the changes in clock speed. The heat constraint also limits the processing power and often the amount of DRAM memory.

Another consequence of the heavy case is the strain on the VESA mounting assembly under constant vibration. Most of the systems weigh about five pounds and require very robust mounting. A modest 10G shock applies 50 pounds to the lever arm of the mounting system, which exceeds the specification of most models and causes the display to move under shock, straining the cables.

Each manufacturer chooses the type and number of I/O based on their market input, but requirements nearly always expand. Adding I/O can be awkward and create complications.

Pros

- All electronics are in one box, minimizing cab clutter
- Normally, no troubleshooting is required – just replace one piece of equipment
- Products are available from several vendors
- Some have internal battery options for shutdown during power loss
- Lowest upfront cost

Cons

- The dash can be cluttered with cables. The routing paths may hinder operator movement
- The amount and type of I/O is limited by the connector space on the tablet
- Generally, the tablets do not have robust connectors. It can be difficult to secure cables against vibration without putting undue stresses on the cable/connector interfaces
- The CPU section of the circuitry generates considerable heat, which is aggravated by the heat from the display backlight and sunlight impinging upon the unit. Semiconductor failure is exponentially proportional to the temperature. The excess heat will cause modern processors to automatically slow execution speed, which should be anticipated in the software design

- Limited performance
- Tend to be heavy, stressing mounting

The second alternative is a modification of the first approach in an attempt to overcome some of the drawbacks. One way to modestly reduce the heat in the tablet is to buy a version without all the I/O except for an Ethernet port. This is connected to an I/O breakout box somewhere else in the cab. Now, only slim Ethernet and power cables go to the tablet. The I/O breakout box must have its own power supply and a CPU of some sort to funnel the I/O through the Ethernet cable. The breakout box will contain software or firmware, so the software on the tablet and breakout box must be developed in parallel.

This two-box approach will be more complicated and costly than in the first approach even though the tablet could be lower in cost.

Pros

- This would solve the need for future expandability
- Assuming the display is the least reliable component during system failure, replacing the display would solve most problems
- Display products are available from multiple vendors at a relatively low cost
- This would slightly reduce the CPU heat problem
- More robust I/O connectors could be used

Cons

- The requirement to have one box would be cast aside
- The assumption has been that the electronics in the I/O box would be minimal. Most likely, this would not be the case. The I/O box would need its own power supply, CPU, I/O and protective circuitry
- The I/O box requires custom design
- The I/O box would need its own software/firmware. This would make software development more complex since two systems may need simultaneous troubleshooting

The final approach is one that is most widely used in the mining and construction markets today. It is a two-piece solution with a simple touchscreen display and CPU box with built in I/O. Due to the much lower power dissipation, heat is no longer an issue in the display. All the I/O circuitry and processor are in a box elsewhere in the cab, with a video cable connected to the display. This approach allows considerable flexibility in the display size and features. Because the processor/I/O box has much more connector space, sealed and special connectors are easily implemented. At least one manufacturer offers customization of I/O. One can install new generations of computers using the same connector pattern as the previous generation. The first two alternatives may meet short-term goals, but will need to be replaced to meet future needs, which will require cabling of the vehicles, resulting in a significant amount of downtime and cost.

Finally, some products are scalable with respect to CPU performance, memory, I/O and wireless devices.

Pros

- The dash is left uncluttered with plenty of room for fatigue monitoring equipment, etc.
- Software development is simplified since the CPU and I/O are integrated.
- Assuming the display would be the least reliable component, during system failure, replacing the display would solve most problems as in the second method.
- Display products are available from multiple vendors at a relatively low cost
- The CPU and display heat generation systems would be completely separate
- More robust I/O connectors could be used

Cons

- The upfront cost is generally the highest, but this is coupled with less downtime.
- Two boxes

Future Needs

As in the whole history of industrial computing, the future has always required faster processors, more memory and more programs running simultaneously. Likewise, this will this continue to be the trend in mining and construction. The heat-limited nature of tablets makes them incompatible with advanced processors needed to run Virtual Machine (VM) software with operating systems like Windows 10.

A thought that is trending is to integrate the functions of several vehicular systems in one enclosure with a large number of I/O ports, and run all the applications under VM. This is simply an expansion of the final approach, keeping the architecture and much of the connectorization the same. While there will always be some applications for simpler systems, the last approach is expected to prevail well into the future.