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(54) **CENTRALIZED ARCHITECTURE FOR IN-VEHICLE ENTERTAINMENT SYSTEMS**

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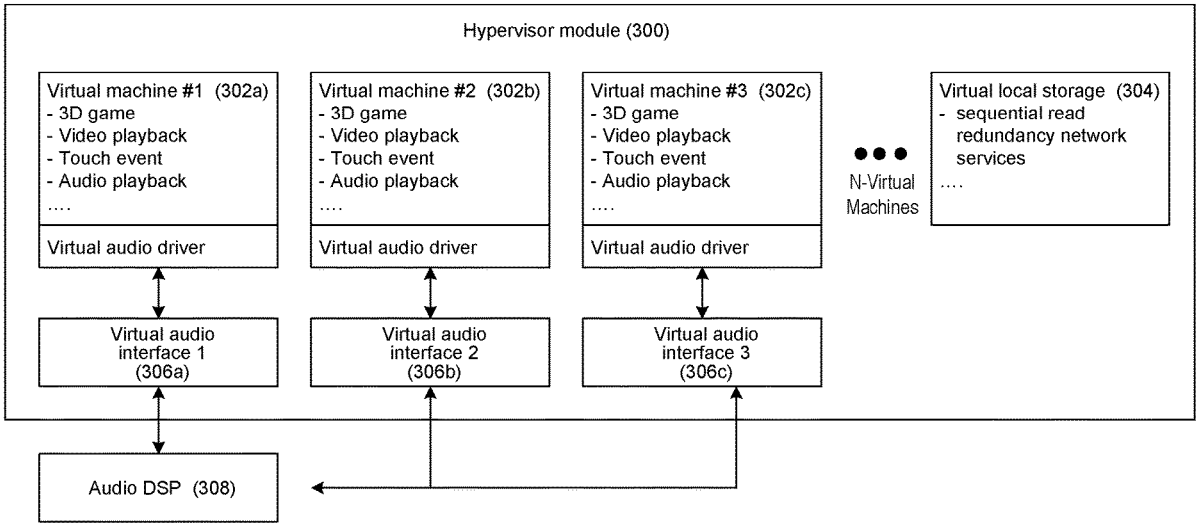
(57) **ABSTRACT**

In-vehicle entertainment (IVE) systems can have a centralized architecture to improve heat dissipation characteristics and weight and/or size of the WE systems. A centralized system for providing in-vehicle entertainment to passengers on a commercial passenger vehicle includes a printed circuit board (PCB) in a housing locatable in a structure in the commercial passenger vehicle and a plurality of display panels and microcontrollers located in a rear portion of the structure. Each microcontroller is communicably connected to one display panel and the PCB. The PCB includes a processor configured to decode audio and/or video content and to operate a plurality of virtual machines that correspond to and perform operations such as playback functionality related to the plurality of display panels.



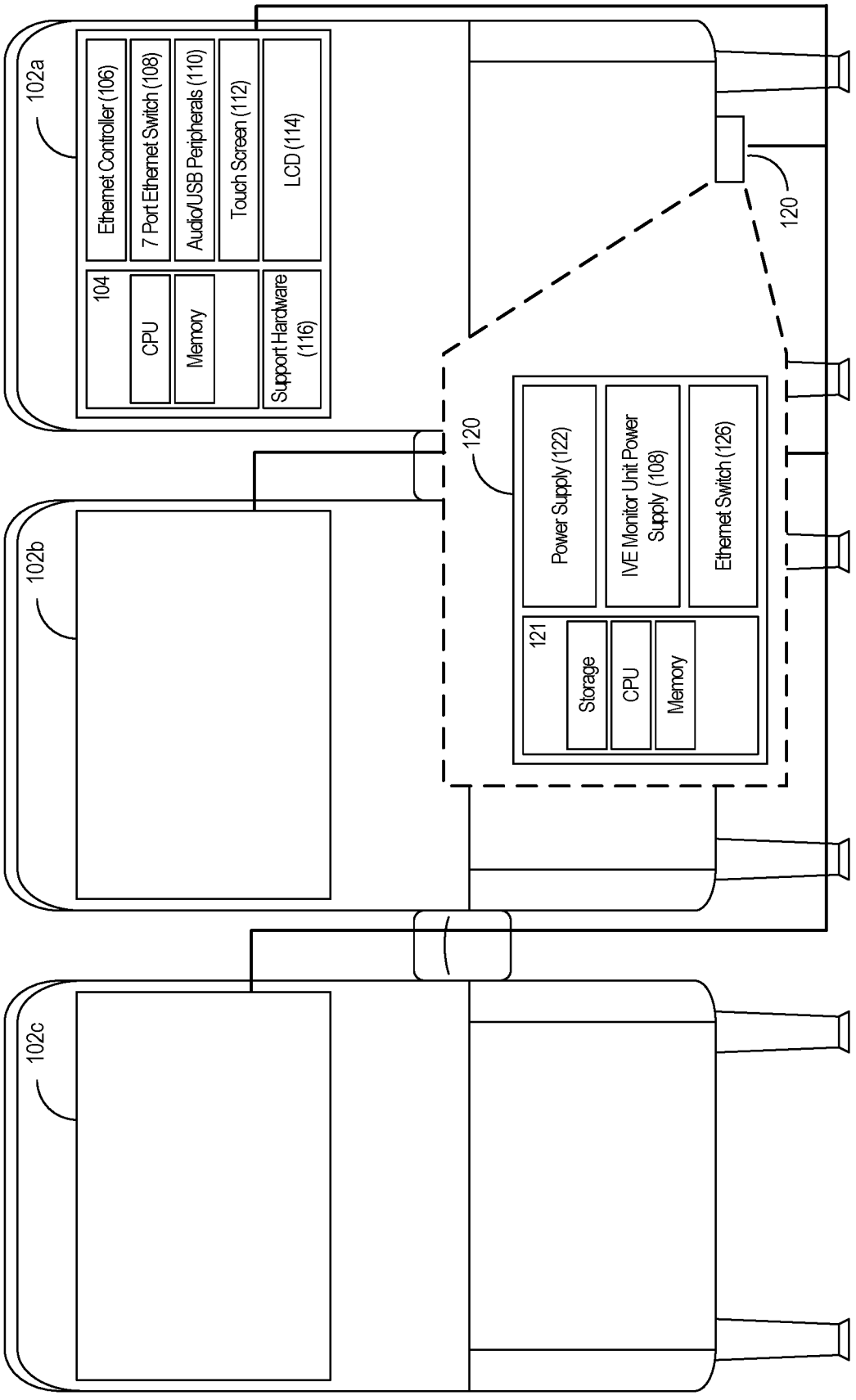

102a
Ethernet Controller (106)
7 Port Ethernet Switch (108)
Audio/USB Peripherals (110)
Touch Screen (112)
LCD (114)
104
CPU
Memory
Support Hardware (116)
120
102b
Power Supply (122)
IVE Monitor Unit Power Supply (108)
Ethernet Switch (126)
121
Storage
CPU
Memory
120
102c

FIG. 1

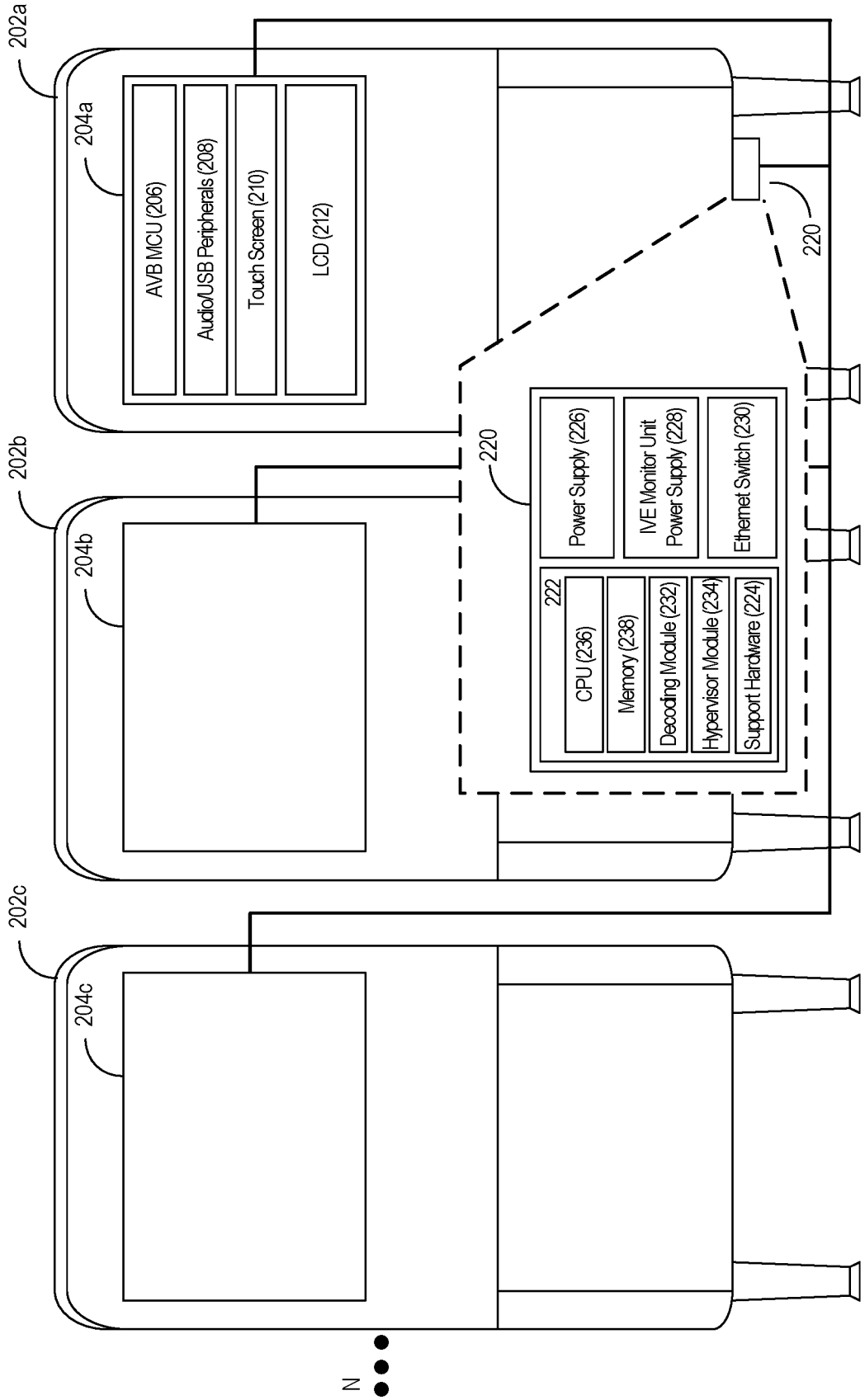

202a
204a
AVB MCU (206)
Audio/USB Peripherals (208)
Touch Screen (210)
LCD (212)
220
202b
204b
220
Power Supply (226)
IVE Monitor Unit Power Supply (228)
Ethernet Switch (230)
222
CPU (236)
Memory (238)
Decoding Module (232)
Hypervisor Module (234)
Support Hardware (224)
202c
204c
N

FIG. 2

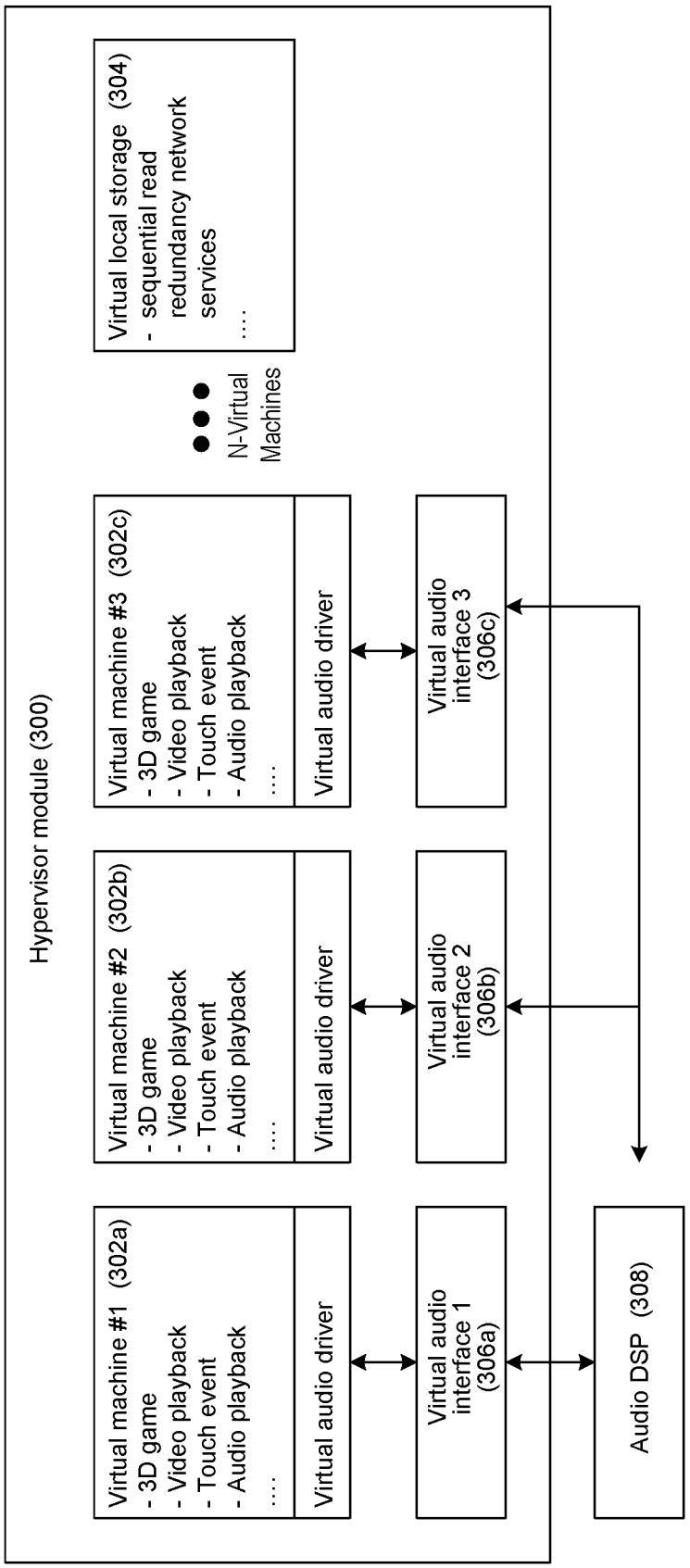

Hypervisor module (300)
Virtual machine #1 (302a)
- 3D game
- Video playback
- Touch event
- Audio playback
....
Virtual audio driver
Virtual audio interface 1 (306a)
Virtual machine #2 (302b)
- 3D game
- Video playback
- Touch event
- Audio playback
....
Virtual audio driver
Virtual audio interface 2 (306b)
Virtual machine #3 (302c)
- 3D game
- Video playback
- Touch event
- Audio playback
....
Virtual audio driver
Virtual audio interface 3 (306c)
N-Virtual Machines
Virtual local storage (304)
- sequential read
redundancy network
services
....
Audio DSP (308)

FIG. 3

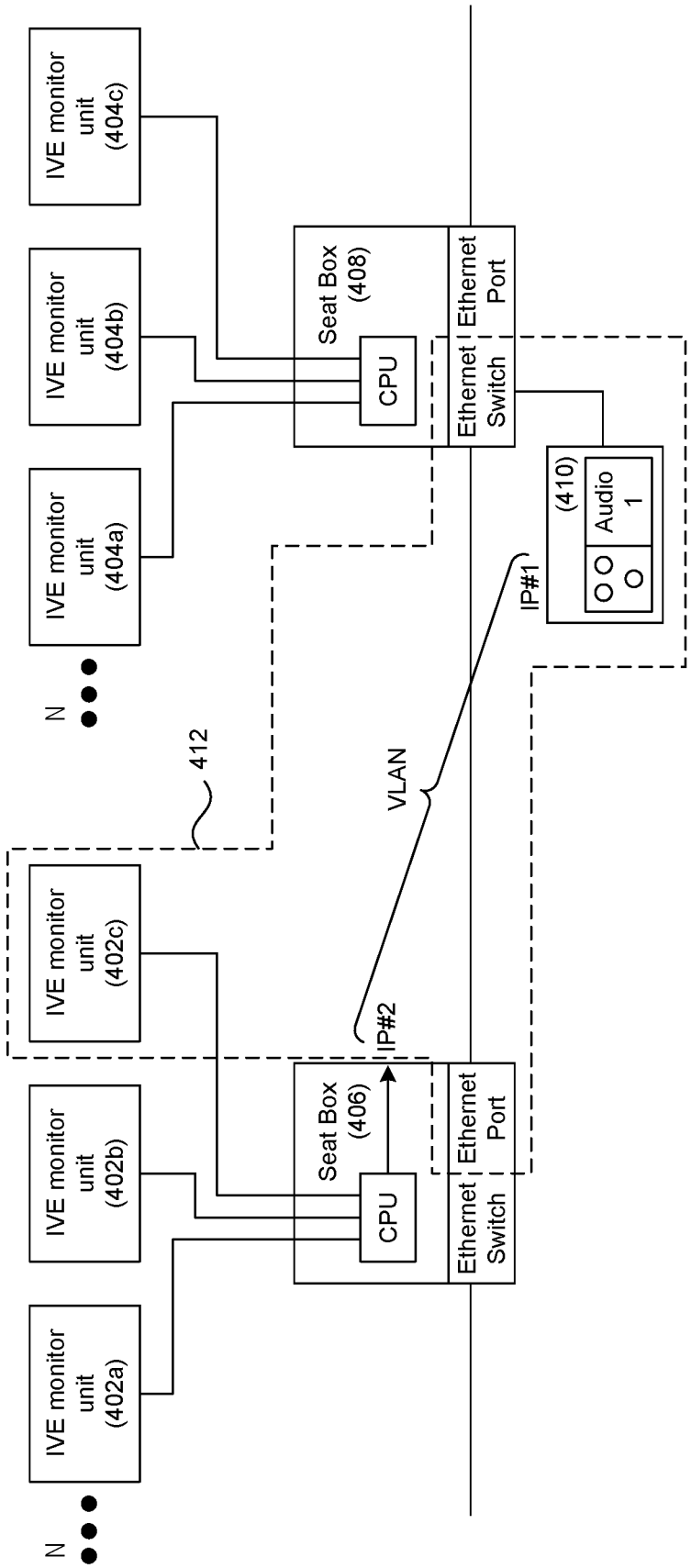

IVE monitor unit (402a)
IVE monitor unit (402b)
IVE monitor unit (402c)
N
412
IVE monitor unit (404a)
IVE monitor unit (404b)
IVE monitor unit (404c)
N
Seat Box (406)
CPU
Ethernet Switch
Ethernet Port
IP#2
VLAN
Seat Box (408)
CPU
Ethernet Switch
Ethernet Port
IP#1
(410)
Audio 1

FIG. 4

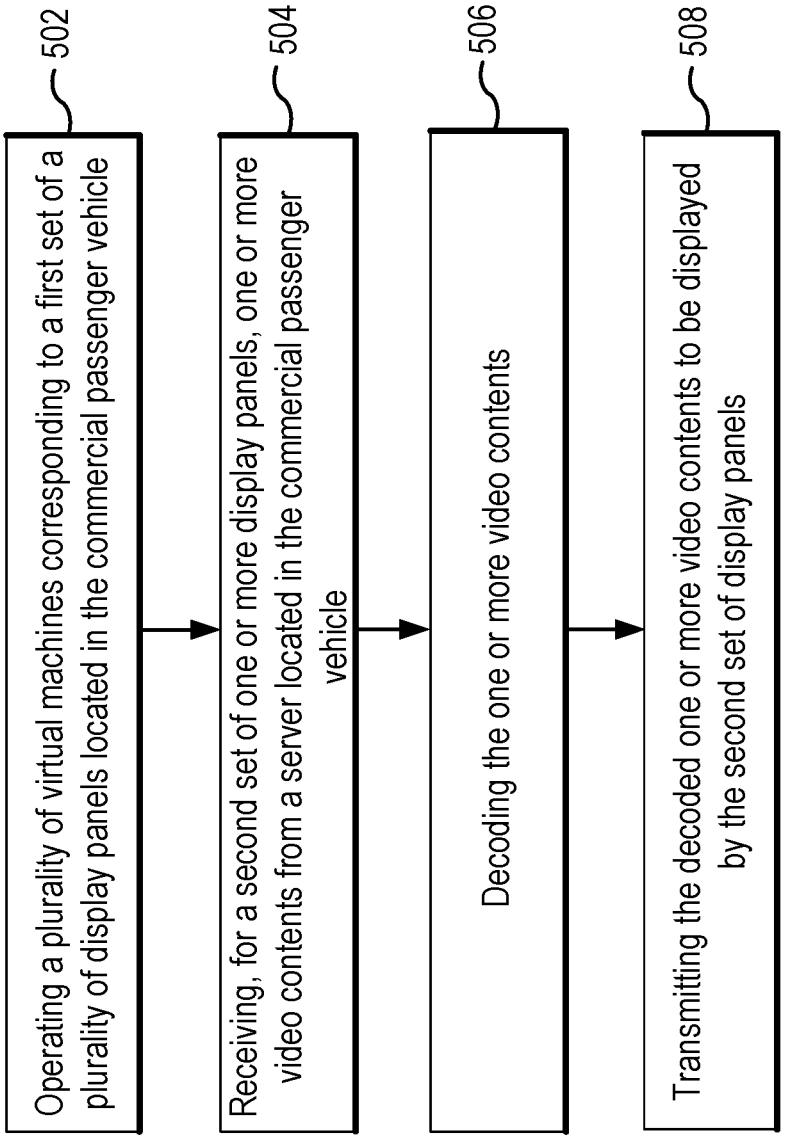

502
Operating a plurality of virtual machines corresponding to a first set of a plurality of display panels located in the commercial passenger vehicle
504
Receiving, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle
506
Decoding the one or more video contents
508
Transmitting the decoded one or more video contents to be displayed by the second set of display panels

FIG. 5

CENTRALIZED ARCHITECTURE FOR IN-VEHICLE ENTERTAINMENT SYSTEMS

TECHNICAL FIELD

[0001] This document is directed generally to in-vehicle entertainment monitor systems in commercial passenger vehicles.

BACKGROUND

[0002] Commercial travel has evolved to provide entertainment options to passengers traveling to their destinations. For example, in an airplane or train, entertainment options are provided on monitors located on the back of seats, where the monitors can enable passengers to watch movies or television shows as they travel to their destinations. The monitors can also provide travel related information to the passengers. For example, passengers can view a map with the current location of the airplane or train and an estimated time of arrival to their destinations. Thus, in-vehicle entertainment systems can be designed to provide passengers with a positive travel experience.

SUMMARY

[0003] This patent document describes a centralized architecture for an in-vehicle entertainment (WE) system so that hardware resources can be shared by a group of monitors in a commercial passenger vehicle.

[0004] An example embodiment describes a centralized system for providing in-vehicle entertainment to passengers on a commercial passenger vehicle, where the centralized system comprises a housing locatable in a structure located in the commercial passenger vehicle, a first set of a plurality of display panels and a plurality of microcontrollers located in a rear portion of the structure. The housing comprises a printed circuit board (PCB) comprising at least one processor configured to operate a plurality of virtual machines corresponding to a first set of a plurality of display panels located in a rear portion of the structure, receive, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, where the first set of display panels comprise the second set of display panels, decode the one or more video contents, and transmit the decoded one or more video contents to be displayed by the second set of display panels, where one or more virtual machines are operable to control playback functionality for the decoded one or more video contents associated with the second set of display panels. The plurality of microcontrollers are located in the rear portion of the structure, where each microcontroller is communicably connected to one display panel and the PCB, and where each microcontroller is configured to receive a decoded video content from the PCB and send the decoded video content to the one display panel to display.

[0005] Another example embodiment describes a method of providing in-vehicle entertainment to passengers on a commercial passenger vehicle, the method comprising operating a plurality of virtual machines corresponding to a first set of a plurality of display panels located in the commercial passenger vehicle, receiving, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, where the first set of display panels comprise the second set of display panels, decoding the one or more video contents, and transmitting the decoded one or more video contents to be displayed by the second set of display panels, where one or more virtual machines control playback functionality for the decoded one or more video contents associated with the second set of display panels.

[0006] In yet another exemplary aspect, the methods described in this patent document, including the above-described methods, are embodied in the form of processor-executable code and stored in a non-transitory computer-readable storage medium. The code included in the non-transitory computer-readable storage medium when executed by a processor, causes the processor to implement the methods described in this patent document.

[0007] In yet another exemplary embodiment, a device that is configured or operable to perform the above-described methods is disclosed.

[0008] The above and other aspects and their implementations are described in greater detail in the drawings, the descriptions, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** shows conventional in-vehicle entertainment (WE) monitor units located on seats in airplanes or other commercial vehicles.

[0010] FIG. **2** shows an exemplary centralized architecture for an WE system for commercial passenger vehicles.

[0011] FIG. **3** shows a block diagram of operations performed by a hypervisor module operating on a printed circuit board (PCB) in a seat box unit.

[0012] FIG. **4** shows an example scenario audio routing performed by the seat box unit.

[0013] FIG. **5** shows an example flowchart of operations performed by a processor in the PCB in the seat box unit.

DETAILED DESCRIPTION

[0014] FIG. **1** shows conventional in-vehicle entertainment (WE) monitor units **102***a*-**102***c* located on a row of three seats in airplanes or other commercial vehicles. The WE monitor units **102***a*-**102***c* are communicably or electrically coupled to a seat box unit **120** that may be located below the seats on which the WE monitor units **102***a*-**102***c* are located. The WE monitor units **102***a*-**102***c* are located on seatbacks of seats in the commercial passenger vehicle. can display video content obtained from the seat box unit **120**. As shown in FIG. **1** and further described below, the WE monitor units **102***a*-**102***c* and the seat box unit **120** includes several electrical components.

[0015] The various components of the conventional seat box unit **120** are shown in an expanded inset. The conventional seat box unit **120** includes a printed circuit board (PCB) **104** that includes a processor, memory, storage (e.g., solid-state drive) and peripherals. The seat box unit **120** also includes the following components that are connected to or in communication with the PCB **120**: power supply **122**, WE monitor unit power supply **124**, and an ethernet switch **126**. The power supply **122** can provide power to the devices or electronics in the PCB **121**, the WE monitor unit power supply **124** can provide power to the devices or electronics in the WE monitor units **102***a*-**102***c*. The ethernet switch **126** in the seat box unit **120** can be connected to ethernet switch **108** of the IVE monitor units **102***a*-**102***c* via ethernet cables.

[0016] The conventional WE monitor units **102***a*-**102***c* can be a standalone device that includes various components

packaged together into one housing to comprise an integrated single device. For ease of description, FIG. **1** shows a block diagram of the components of only the WE monitor unit **102***a*. The WE monitor units **102***b*-**102***c* have the same components as those shown for WE monitor unit **102***a*. The WE monitor unit **102***a* includes its own PCB **104** that includes a processor, memory, and peripherals. The IVE monitor unit **102***a* may also include the following components that are connected to or in communication with the PCB **104**: ethernet controller **106**, ethernet switch **108**, audio or USB peripherals **110**, touch screen (or display) **112**, an optional liquid crystal display (LCD) **114**. The WE monitor unit **102***a* also includes a support hardware **116** that can enable the WE monitor unit **102***a* to perform the various operations related to audio or video content reception (e.g., power regulator, ethernet transceiver, etc.,). There are several technical drawbacks to the conventional WE monitor unit.

[0017] Conventional WE monitor units **102***a*-**102***c* tend to generate significant heat at least because the various components of an WE monitor unit are integrated into a single device. For example, the integrated WE monitor unit **102***a* may generate significant heat when a processor on a PCB **104** decodes audio and/or video while the monitor **112** displays the video content. While active or passive cooling options can be added to dissipate heat in a conventional WE monitor unit, such designs can increase the mechanical design complexity, the cost, and the overall dimensions of a conventional WE monitor unit. Furthermore, the heat generated by a conventional WE monitor unit can deteriorate the performance or lifespan of the various components within the conventional WE monitor unit. For example, the processor on the PCB **104** may reduce the performance of internal processor **112** if the temperature of the WE monitor unit **102***a* exceeds a pre-determined limit.

[0018] Convention IVE monitor units **102***a*-**102***c* have additional technical drawbacks. For example, if a bigger display panel is required, most likely the entire integrated IVE monitor unit **102***a* will have to be designed and/or replaced, even if the performance of the PCB **104** in the WE monitor unit **102***a* is sufficient for the bigger display panel. In another example, if the devices or electronics within the WE monitor unit **102***a* needs an upgrade for higher performance or lower power consumption while keeping the same display panel **112**, the entire integrated IVE monitor unit **102***a* will have to be designed and/or replaced. Thus, the parts in the conventional WE monitor units **102***a*-**102***c* are difficult to replace or upgrade, which can add significant cost to customers of the conventional IVE monitor units.

[0019] To overcome at least these technical drawbacks, among others, this patent document describes centralized architectures for IVE systems. The centralized architecture can enable hardware resources to be shared by a group of monitors in the WE systems. One of the technical benefits of the centralized architecture is that the various parts of the IVE system can be easily upgraded or replaced without affecting the other parts of the WE system. Compared to the conventional integrated WE monitor unit, the exemplary WE monitor units described in this patent document can have improved heat dissipation characteristics at least because some of the components of the WE system can be separated and located in different places in, for example, a seat of a commercial passenger vehicle. Furthermore, the centralized architecture can enable the exemplary IVE monitor units to be designed with reduced weight and mechanical dimensions, which is a beneficial technical feature for commercial passenger vehicles (e.g., airplanes) that may have strict limits on the amount of space and/or weight of the IVE monitor units installed in the commercial passenger vehicles.

[0020] FIG. **2** shows an exemplary centralized architecture for an IVE system for commercial passenger vehicles. The centralized architecture of an IVE system includes IVE monitor units **204***a*-**204***c* installed on or in a structure (e.g., on a rear portion or seatback of a row of three seats **202***a*-**202***c*) of a commercial passenger vehicle, such as an airplane, train, a ship, or a bus. The centralized architecture of the IVE system also includes a seat box unit **220** that may be located in an enclosure or housing below the seats **202***a*-**202***c*. For ease of description, FIG. **2** shows a block diagram of the components of only the IVE monitor unit **204***a*. The IVE monitor units **204***b*-**204***c* have the same components as those shown for IVE monitor unit **204***a*. FIG. **2** shows an example of a three-seat implementation, in some embodiments, the centralized architecture can be implemented from two-seats up to N-seats as indicated to the left of seat **202***c*. In some embodiments, the centralized architecture of FIG. **2** can be implemented for a structure comprising a single seat.

[0021] The IVE monitor unit **202***a* includes an audio video bridging microcontroller **206** (AVB microcontroller) that is communicably (or electrically) connected to and/or in communication with a PCB **222** located in the seat box unit **220**. For example, the AVB microcontroller **206** can be connected via an ethernet cable the PCB **222**. Video content is decoded by decoding module **232** of the PCB **222** and can be sent to monitor unit **204** directly for display. The IVE monitor unit **204***a* may also include audio and/or universal serial bus (USB) peripherals **208** (e.g., audio jack and/or USB connector), where the AVB microcontroller **206** can control the audio and/or USB peripherals (e.g., by sending decoded audio content to the audio jack). The AVB microcontroller **206** and the audio/USB peripherals **208** can be located on a PCB that can be located in a seatback where the touch screen display **210** may be installed. In some embodiments, the AVB microcontroller may be an ethernet device that supports the AVB standard.

[0022] The IVE monitor unit **204** also includes a touch screen display **210** to display the received decoded video content, and an optional liquid crystal display (LCD) **212** that can be used to turn on/off the touch screen display **210**, increase or decrease volume, and/or increase or decrease touch screen display **210** brightness. In some embodiments, the touch screen display **210** can have a 1080p or 4K resolution.

[0023] The various components of the exemplary seat box unit **220** are shown in an expanded inset. A commercial passenger vehicle can include a plurality of seat box units **220**, where each seat box unit **220** includes a PCB **222** that is communicably connected to and/or in communication with a group of AVB microcontrollers **206** located in their respective monitor units **204***a*-**204***c*. In an example embodiment, as shown in FIG. **2**, PCB **222** in a seat box unit **220** can be communicably connected to and/or in communication with three WE monitor units' **204***a*-**204***c* AVB microcontrollers **206**.

[0024] The PCB **222** includes one or more processors **236** and a memory **238** having instructions stored thereupon. The

instructions upon execution by the at least one processor **236** configure the at least one processor **236** to perform the operations described for the decoding module **232**, the hypervisor module **234** and/or the various embodiments described in this patent document. The PCB **222** can be communicably connected to the AVB microcontrollers **206** via the ethernet switch **230**. The PCB **222** can be electrically connected to an ethernet switch **230** located in the seat box unit **220**, where the ethernet switch **230** can route or send Internet Protocol (IP) traffic to the AVB microcontrollers **206** in the WE monitor units **204***a*-**204***c*, and where the ethernet switch **230** can be communicably connected to and can receive audio and/or video content from the edge server located in the commercial passenger vehicle.

[0025] The number of monitor units **214** which the seat box unit's PCB **222** can be connected can depend on a resolution of the touch screen display **210**. For example, if the touch screen display **210** has a resolution of 1080p, then the PCB **222** can be communicably connected to and/or in communication with three WE monitor units **204***a*-**204***c*. In another example, if the touch screen display **210** has a resolution of 4K, then the PCB **222** can be communicably connected to and/or in communication with two WE monitor units' **204***a*-**204***b* AVB microcontrollers **206** that may be located in rear portions of two seats.

[0026] In some embodiments, the seat box unit **220** may include a single housing in which the PCB **220** may be located. In some embodiments, a same housing or enclosure for the seat box unit **220** may be used to include more than one identical PCBs **222** so that high resolution decoded video content can be sent to touch screen displays having a high resolution (e.g., 4K). For example, a first PCB **222** in a seat box unit **220** may be communicably connected to and/or in communication with two IVE monitor units **204***a*-**204***b*, and a second PCB **222** in the same seat box unit **220** may be communicably connected to and/or in communication with the monitor unit **204***c*. Thus, the centralized architecture can provide a scalable the seat box unit **220**.

[0027] The seat box unit **220** also includes the following components that may be communicably connected to or in communication with the PCB **222**: power supply **226** and IVE monitor unit power supply **228**. The power supply **226** can provide power to the devices or electronics in the PCB **222**, and the IVE monitor unit power supply **228** can provide power to the devices or electronics in the IVE monitor units **204***a*-**204***c*. The PCB **222** may include an ethernet transceiver that receives information from the ethernet switch **230** in the seat box unit **220**. The PCB **222** also includes a support hardware **224** that can enable the at least one processor **236** on the PCB **222** to perform the various operations related to audio or video content reception. For example, the support hardware **224** can include power regulator, ethernet transceiver, and/or audio digital signal processor (audio DSP).

[0028] In the centralized architecture, the decoding module **232** of the PCB **222** can receive audio and/or video content from the edge server, decode the audio and/or video content, and send the decoded audio and/or video content to the IVE monitor unit **204***a*. For example, the decoding module **232** may use a video codec to decode digital video content that may have been encoded using the H.264, H.265 or MPEG standard. In the centralized architecture, the hypervisor module **234** of the PCB **222** can perform a number of operations as further described in FIG. **3**.

[0029] FIG. **3** shows a block diagram of operations performed by a hypervisor module of the centralized architecture. A list of operations that can be performed by the hypervisor is first provided followed by a detailed explanation below. The hypervisor module **300** can operate a number of virtual machine operating systems, perform resource arbitration, provide a virtual network interface, provide graphic processor unit (GPU) sharing, and/or multi stream audio processing. FIG. **3** shows an example of a three-virtual machines that can correspond to three IVE monitor units. In some embodiments, the centralized architecture can be implemented from two-virtual machines up to N-virtual machines as indicated to the right of virtual machine #**2** **302***c*. In some embodiments, the centralized architecture of FIG. **3** can be implemented for a single virtual machine. In some embodiments the GPU may be part of the one or more processors of the PCB in the seat box unit. In some embodiments, the hypervisor module **300** can also perform video decoding and/or encoding of video content received from an edge server located in the commercial passenger vehicle.

[0030] In FIG. **3**, the hypervisor module can create and operate a number of virtual machines, where each virtual machine can perform operations related to one IVE monitor unit, and where each virtual machine can a privileged virtual machine operating system. For example, virtual machine #**1** **302***a* can perform operations associated with IVE monitor **204***a*, virtual machine #**2** **302***b* can perform operations associated with IVE monitor **204***b*, virtual machine #**3** **302***c* can perform operations associated with IVE monitor **204***c*, and so on. The hypervisor module can independently operate each virtual machine to perform one or more operations related to 3D game, video playback, touch event (e.g., when a person touches the touch screen display), audio playback, etc., For example, if a person touches a playback button (e.g., "play" or "pause") displayed on a graphical user interface (GUI) on a touch screen display of a IVE monitor **204***a*, the virtual machine #**1** operating in the hypervisor module can perform an operation indicated by the touched playback button.

[0031] The hypervisor module **300** can also arbitrate and buffer input/output (I/O) requests from one or more operating systems operated by the one or more processors of the PCB of the seat box unit, can add security checks for accessing peripherals, can arbitrate memory resources, can resolve memory and I/O contention in multiple simultaneous I/O requests, and can add memory protection and error handling. In some embodiments, the hypervisor module **300** can include support for operating multiple operations systems concurrently by the one or more processors of the PCB of the seat box unit. In some embodiments, hypervisor module and/or the virtual machines may perform their operations by sharing memory resources from a same memory in the PCB in the seat box unit.

[0032] The hypervisor module **300** can also perform operations related to a virtual local storage such as by performing sequential read redundancy network services. The operations related to the virtual local storage and redundant network services are described in U.S. Pat. Nos. 9,961,373, 10,097,603, and/or 10,348,832. The entire contents of the above identified U.S. Patents are incorporated by reference in its entirety for all purposes in this patent document.

[0033] FIG. **3** also shows the hypervisor module receiving decoded audio from an audio DSP **308** that can be part of the support hardware in the PCB of the seat box unit, as described in FIG. **2**. The audio DSP **308** can include an audio codec that can decode audio content received from the edge server on the commercial passenger vehicle. The audio content received from the edge server may relate to the video content being displayed on a touch screen display of an IVE monitor unit. The hypervisor module can operate each virtual machine to include a virtual audio driver that can receive the decoded audio content corresponding to the virtual machine via a respective virtual audio interface (or software audio interface). For example, virtual audio driver for virtual machine #**1** can receive decoded audio content from virtual audio interface **1 306***a*, virtual audio driver for virtual machine #**2** can receive decoded audio content from virtual audio interface **2 306***b*, and so on. The virtual audio interfaces **1-3 306***a*-**306***c* receive audio content from the audio DSP **308**. Each virtual machine can send the decoded audio content to an AVB microcontroller in an IVE monitor unit associated with that virtual machine, where the AVB microcontroller sends the decoded audio content to the audio connector or headphone jack associated with the IVE monitor unit. The hypervisor module **300** can separate the decoded audio content received by the hypervisor module **300** from the audio DSP **308** so that the decoded audio content can properly sent to each virtual machine for audio playback.

[0034] FIG. **4** shows an example scenario audio routing performed by the seat box unit. In the example scenario of FIG. **4**, the IVE monitor units **402***a*-**402***b* with displays are located on a row that is immediately in front of the IVE monitor units **404***a*-**404***b* with displays. FIG. **4** shows an example of a three-seat implementation with three IVE monitor units. In some embodiments, the centralized architecture can be implemented from two-seats with two IVE monitor units up to N-seats with N-IVE monitor units as indicated to the left of IVE monitor units **402***a*, **404***a*. In some embodiments, the centralized architecture of FIG. **4** can be implemented for structure comprising a single IVE monitor unit.

[0035] In some implementations, one or more headphone audio jacks **410** for content displayed on a display for IVE monitor **402***c* are located on the seat on whose seatback is installed the IVE monitor unit **404***c*. To enable decoded audio from the audio DSP to be routed to the headphone audio jack(s) **410**, the hypervisor module can create a virtual LAN (VLAN) **412** that includes the IP addresses (e.g., IP #**1**, IP #**2**) of the seat box units **406** and **408**. Decoded audio can be routed to the proper seat box using based on an IP address (e.g., IP #**1**) of the seat box unit associated with the head phone jack(s) **410**. In some other implementations, the headphone audio jack(s) **410** for content displayed on IVE monitor unit **402***c* can be located next to the IVE monitor unit **402***c* so that the hypervisor module of the PCB of seat box unit **406** can decode and send audio to the headphone audio jack **410**.

[0036] The operations performed by the decoder module and the hypervisor module provide several technical benefits over conventional technology. For example, in conventional WE systems, the WE monitor units decode video sent by the PCB in the seat box unit. In the exemplary centralized architecture, the decoder module can decode video and can send the decoded video to the monitor unit. As mentioned above, conventional IVE monitor units can be designed to manage the heat dissipated due to video decoding, however such designs can increase the mechanical design complexity, the cost, and the overall dimensions of a conventional WE monitor unit. By having the decoding module decode the video in the seat box unit, the centralized architecture can better manage heat dissipation caused by video decoding at least because active cooling option(s) (e.g., fan) and/or passive cooling option(s) (e.g., heatsink) can be more easily added to the seat box units that may be located in seats. Furthermore, since seat box units can be located in seats and may not be noticed by passengers, cooling option(s) can be added to seat box units while minimizing the impact of any increased size of the seat box unit on the passengers' perception of the amount of space available to them.

[0037] The hypervisor module also provides several technical advantages. For example, a conventional WE systems can utilize at least four processors and memories for a group comprising a seat box unit and three WE monitor units (as shown in FIG. **1**). Such a system, however, tends to waste computational resources at least because each of the at least four processors and memories may not be adequately utilized up to their capabilities. For example, if passengers do not wish to operate their IVE monitor units, the processors in such units may still consume power and may be powered on just in case the passengers want to operate their WE monitor units. Unlike the conventional IVE systems, the exemplary centralized architecture includes a hypervisor module that can enable one or more processors located in a seat box unit to more effectively utilize the one or more processors' available computational resources and can also share resources (e.g., memory) on the PCB of the seat box unit. Accordingly, the hypervisor module can minimize waste associated with multiple processors being deployed on conventional WE monitor units where the multiple processors may not be adequately utilized.

[0038] FIG. **5** shows an example flowchart of operations that can be performed by a processor in the PCB in the seat box unit to provide in-vehicle entertainment to passengers on a commercial passenger vehicle. Operation **502** includes operating a plurality of virtual machines corresponding to a first set of a plurality of display panels located in the commercial passenger vehicle.

[0039] Operation **504** includes receiving, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, where the first set of display panels comprise the second set of display panels. In some embodiments, a number of the second set of one or more panels may be less than or equal to a number of the first set of one or more panels at least because, based on passengers' preferences, a number of display panels for which video content may be requested can be less than or equal to a number of display panels that can display video content. Operation **506** includes decoding the one or more video contents. Operation **508** includes transmitting the decoded one or more video contents to be displayed by the second set of display panels, where one or more virtual machines control playback functionality for the decoded one or more video contents associated with the second set of display panels.

[0040] In some embodiments, the one or more virtual machines share memory resources from a memory device. In some embodiments, the method of FIG. **5** further comprises decoding one or more audio contents corresponding to the

one or more virtual machines, where the one or more virtual machines receive and send the decoded one or more audio contents to one or more audio connectors corresponding to the one or more virtual machine. In some embodiments, the one or more audio content corresponds to the one or more video contents for the second set of display panels.

[0041] In some embodiments, the operating of the plurality of virtual machines, the receiving of the one or more video contents, the decoding of the one or more video contents, and the transmitting of the decoded one or more video contents are performed by a processor on a printed circuit board (PCB) located in a housing below the first set of display panels. In some embodiments, the first set of display panels are located in a rear portion of a structure in the commercial passenger vehicle. In some embodiments, the structure comprises at least two seats in the commercial passenger vehicle.

[0042] An example embodiment describes a centralized system for providing in-vehicle entertainment to passengers on a commercial passenger vehicle, where the centralized system comprises a housing locatable in a structure located in the commercial passenger vehicle, a first set of a plurality of display panels and a plurality of microcontrollers located in a rear portion of the structure. The housing includes a printed circuit board (PCB) comprising at least one processor configured to operate a plurality of virtual machines corresponding to a first set of a plurality of display panels located in a rear portion of the structure, receive, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, where the first set of display panels comprise the second set of display panels, decode the one or more video contents, and transmit the decoded one or more video contents to be displayed by the second set of display panels, where one or more virtual machines are operable to control playback functionality for the decoded one or more video contents associated with the second set of display panels. The centralized system also includes a plurality of microcontrollers located in the rear portion of the structure, where each microcontroller is communicably connected to one display panel and the PCB, and where each microcontroller is configured to receive a decoded video content from the PCB and send the decoded video content to the one display panel to display.

[0043] In some embodiments, the one or more virtual machines are operable to share memory resources from a memory device located on the PCB. In some embodiments, the PCB comprises an audio digital signal processor (DSP) operable to decode one or more audio contents, the decoded one or more audio contents correspond to the one or more virtual machines, and the one or more virtual machines are operable to receive and send the decoded one or more audio contents to one or more audio connectors corresponding to the one or more virtual machine. In some embodiments, the one or more audio content corresponds to the one or more video contents for the second set of display panels.

[0044] In some embodiments, the structure comprises at least two seats in the commercial passenger vehicle. In some embodiments, the first set of display panels are located above the housing. In some embodiments, the housing includes a fan or a heat sink. In some embodiments, the first set of display panels includes touch panels.

[0045] This patent document describes the centralized architecture technology in the context of a structure comprising three seats and three WE monitor units for ease of description. In some embodiments, the centralized architecture technology described in this patent document can be implemented on a structure comprising two seats that include two WE monitor units or a structure comprising up to N-seats that include up to N-WE monitor units. In some embodiments, the centralized architecture technology described in this patent document can also be implemented on a structure comprising a single seat with a single IVE monitor unit.

[0046] Some of the embodiments described herein are described in the general context of methods or processes, which may be implemented in one embodiment by a computer program product, embodied in a computer-readable medium, including computer-executable instructions, such as program code, executed by computers in networked environments. A computer-readable medium may include removable and non-removable storage devices including, but not limited to, Read Only Memory (ROM), Random Access Memory (RAM), compact discs (CDs), digital versatile discs (DVD), etc. Therefore, the computer-readable media can include a non-transitory storage media. Generally, program modules may include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Computer- or processor-executable instructions, associated data structures, and program modules represent examples of program code for executing steps of the methods disclosed herein. The particular sequence of such executable instructions or associated data structures represents examples of corresponding acts for implementing the functions described in such steps or processes.

[0047] Some of the disclosed embodiments can be implemented as devices or modules using hardware circuits, software, or combinations thereof. For example, a hardware circuit implementation can include discrete analog and/or digital components that are, for example, integrated as part of a printed circuit board. Alternatively, or additionally, the disclosed components or modules can be implemented as an Application Specific Integrated Circuit (ASIC) and/or as a Field Programmable Gate Array (FPGA) device. Some implementations may additionally or alternatively include a digital signal processor (DSP) that is a specialized microprocessor with an architecture optimized for the operational needs of digital signal processing associated with the disclosed functionalities of this application. Similarly, the various components or sub-components within each module may be implemented in software, hardware or firmware. The connectivity between the modules and/or components within the modules may be provided using any one of the connectivity methods and media that is known in the art, including, but not limited to, communications over the Internet, wired, or wireless networks using the appropriate protocols.

[0048] While this document contains many specifics, these should not be construed as limitations on the scope of an invention that is claimed or of what may be claimed, but rather as descriptions of features specific to particular embodiments. Certain features that are described in this document in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub-combination.

Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub-combination or a variation of a sub-combination. Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results.

[0049] Only a few implementations and examples are described, and other implementations, enhancements and variations can be made based on what is described and illustrated in this patent document.

1. A centralized architecture system for providing in-vehicle entertainment to passengers on a commercial passenger vehicle, the centralized architecture system comprising:

a housing of the centralized architecture system locatable in a structure located in the commercial passenger vehicle, wherein the housing comprises:

a printed circuit board (PCB) comprising at least one processor configured to:

independently operate each of a plurality of virtual machines corresponding to a first set of display panels located in a rear portion of the structure, wherein each virtual machine has a privileged virtual operating system and is operable to perform operations related to an individual display panel of the first set of display panels;

receive, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, wherein the first set of display panels comprise the second set of display panels;

decode the one or more video contents; and

transmit the decoded one or more video contents to be displayed by the second set of display panels, wherein each of the plurality of virtual machines is independently operable to control playback functionality for the decoded one or more video contents associated with each display panel of the second set of display panels; and

a plurality of audio video bridging microcontrollers located in the rear portion of the structure and communicatively coupled to receive audio and video content from an edge server located on the commercial passenger vehicle,

wherein each audio video bridging microcontroller is communicably connected to one display panel and the PCB, and

wherein each audio video bridging microcontroller is configured to receive a decoded video content from the PCB and send the decoded video content to the one display panel to display,

wherein the housing and the first set of display panels of the centralized architecture system are independently replaceable in response to a higher performance or a lower power consumption related upgrade.

2. The system of claim **1**,

wherein the housing includes a plurality of PCBs that comprise the PCB and a second PCB,

wherein the one or more virtual machines are operable to share memory resources and a same memory from a memory device located on the PCB,

wherein a first display panel and a second display panel of the first set of display panels are communicably coupled to the PCB based on a first display resolution of the first display panel and the second display panel, and

wherein a third display panel is communicably coupled to the second PCB based on a second display resolution of the third display panel, and

wherein the second display resolution is higher than the first display resolution.

3. The system of claim **1**,

wherein the PCB comprises an audio digital signal processor (DSP) operable to decode one or more audio contents,

wherein the decoded one or more audio contents correspond to the one or more virtual machines, and

wherein the one or more virtual machines are operable to receive and send the decoded one or more audio contents to one or more audio connectors corresponding to the one or more virtual machine.

4. The system of claim **3**, wherein the one or more audio content corresponds to the one or more video contents for the second set of display panels.

5. The system of claim **1**, wherein the structure comprises at least two seats in the commercial passenger vehicle.

6. The system of claim **1**, wherein the first set of display panels are located above the housing.

7. The system of claim **1**, wherein the housing includes a fan or a heat sink.

8. The system of claim **1**, wherein the first set of display panels includes touch panels.

9. A method of providing in-vehicle entertainment to passengers on a commercial passenger vehicle, the method comprising:

independently operating each of a plurality of virtual machines corresponding to a first set of display panels located in the commercial passenger vehicle, wherein each virtual machine has a privileged virtual operating system and performs operations related to an individual display panel of the first set of display panels;

receiving, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, wherein the first set of display panels comprise the second set of display panels;

decoding the one or more video contents; and

transmitting the decoded one or more video contents to be displayed by the second set of display panels, wherein each of the plurality of virtual machines controls playback functionality for the decoded one or more video contents associated with each display panel of the second set of display panels.

10. The method of claim **9**, wherein the one or more virtual machines share memory resources and a same memory from a memory device.

11. The method of claim **9**, further comprising:

decoding one or more audio contents corresponding to the one or more virtual machines, wherein the one or more virtual machines receive and send the decoded one or more audio contents to one or more audio connectors corresponding to the one or more virtual machine.

12. The method of claim **11**, wherein the one or more audio content corresponds to the one or more video contents for the second set of display panels.

13. The method of claim **9**, wherein the operating of the plurality of virtual machines, the receiving of the one or more video contents, the decoding of the one or more video contents, and the transmitting of the decoded one or more video contents are performed by a processor on a printed circuit board (PCB) located in a housing below the first set of display panels.

14. The method of claim **9**, wherein the first set of display panels are located in a rear portion of a structure in the commercial passenger vehicle.

15. The method of claim **13**, wherein the structure comprises at least two seats in the commercial passenger vehicle.

16. A non-transitory computer readable program storage medium having code stored thereon, the code, when executed by a processor, causing the processor to:

independently operate each of a plurality of virtual machines corresponding to a first set of a plurality of display panels located in a commercial passenger vehicle, wherein each virtual machine has a privileged virtual operating system and is operable to perform operations related to an individual display panel of the first set of display panels;

receive, for a second set of one or more display panels, one or more video contents from a server located in the commercial passenger vehicle, wherein the first set of display panels comprise the second set of display panels;

decode the one or more video contents; and

transmit the decoded one or more video contents to be displayed by the second set of display panels, wherein each of the plurality of virtual machines is independently operable to control playback functionality for the decoded one or more video contents associated with each display panel of the second set of display panels.

17. The non-transitory computer readable program storage medium of claim **16**, wherein the one or more virtual machines share memory resources and a same memory from a memory device.

18. The non-transitory computer readable program storage medium of claim **16**, wherein the processor is further configured to:

decode one or more audio contents corresponding to the one or more virtual machines, wherein the one or more virtual machines receive and send the decoded one or more audio contents to one or more audio connectors corresponding to the one or more virtual machine.

19. The non-transitory computer readable program storage medium of claim **18**, wherein the one or more audio content corresponds to the one or more video contents for the second set of display panels.

20. The non-transitory computer readable program storage medium of claim **16**, wherein the first set of display panels are located in a rear portion of a structure in the commercial passenger vehicle.

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