REDUNDANCY IN A PUBLIC SAFETY DISTRIBUTED ANTENNA SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 62/335,383, filed on May 12, 2016, entitled "Redundancy in a Public Safety Distributed Antenna System," the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

BACKGROUND OF THE INVENTION

[0002] Public Safety communication systems employing Distributed Antenna Systems (DAS) are available. Public Safety has stringent requirements on system reliability and redundancy. A DAS typically includes one or more host units, optical fiber or other suitable transport infrastructure, and multiple remote antenna units. A radio base station is often employed at the host unit location commonly known as a base station hotel, and the DAS provides a means for distribution of the base station's downlink and uplink signals among multiple remote antenna units. The DAS architecture with routing of signals to and from remote antenna units can be either fixed or reconfigurable.

[0003] A DAS is advantageous from a signal strength and throughput perspective because its remote antenna units are physically close to wireless subscribers. The benefits of a DAS include reducing average downlink transmit power and reducing average uplink transmit power, as well as enhancing quality of service and data throughput.

[0004] Despite the progress made in public safety communications systems, a need exists for improved methods and systems related to public safety communications.

SUMMARY OF THE INVENTION

[0004a] According to a first aspect of the present invention, there is provided a redundancy system for data transport in a Distributed Antenna System (DAS), the redundancy system including: a plurality of Digital Access Units (DAUs) including a primary DAU and a secondary DAU, wherein each of the plurality of DAUs is fed by a plurality of data streams and is operable to transport digital signals between others of the plurality of DAUs; a plurality of Digital Distribution Units (DDUs) including a primary DDU and a secondary DDU, the primary DDU being communicatively coupled to the primary DAU and the secondary DAU, the secondary DDU being communicatively coupled to the primary DAU and the secondary DAU; and a plurality of Digital Remote Units (DRUs) including a primary DRU and a secondary DRU, the primary DRU being communicatively coupled to the primary DDU and the secondary DDU, the secondary DRU being communicatively coupled to the primary DDU

and the secondary DDU; a digital signal processing (DSP) unit configured to detect a failure in the DAS and redirect one or more data streams of the plurality of data streams through the DAS relative to the detected failure.

[0004b] According to a second aspect of the present invention, there is provided a Distributed Antenna System (DAS) including: a primary integrated digital access unit (DAU) having a first input port, a second input port, a first output port, and a second output port; a secondary integrated DAU having a first input port, a second input port, a first output port, and a second output port; a connection between the primary integrated DAU and the secondary integrated DAU; a first digital distribution unit (DDU) having: a first input port coupled to the first output port of the primary integrated DAU; a second input port coupled to the first output port of the secondary integrated DAU; a first output port; and a second output port a second DDU having: a first input port coupled to the second output port of the primary integrated DAU; and a second input port coupled to the second output port of the secondary integrated DAU; a first output port; and a second output port; a first digital remote unit having: a first input port coupled to the first output port of the first DDU; a second input port coupled to the first output port of the second DDU; and an RF output port; a second digital remote unit having: a first input port coupled to the second output port of the first DDU a second input port coupled to the second output port of the second DDU; and an RF output port a digital signal processing (DSP) unit configured to detect a failure in the DAS and redirect one or more data streams of the plurality of data streams through the DAS relative to the detected failure.

[0005] Embodiments of the present invention generally relate to public safety communication systems employing Distributed Antenna Systems (DAS) as part of a distributed wireless network. More specifically, the present invention relates to a DAS utilizing a software configurable network. In a particular embodiment, the present invention has been applied to the use of cross-coupled connections amongst Digital Host Units, Digital Distributed Units and Digital Remote Radios. The methods and systems described herein are applicable to a variety of communications systems including systems utilizing various communications standards. Utilizing embodiments of the present invention, fully redundant, self-monitoring, self-healing digital DAS are provided.

[0006] Public Safety network operators face the continuing challenge of building reliable networks. Mobility and an increased level of multimedia content for end users typically employs end-to-end network adaptations that support new services and the increased demand for broadband Internet access. One of the most difficult challenges faced by Public Safety networks is the ability to have 99.999% service availability throughout the network. Fire-fighters, Police, Homeland Security, etc. all need guaranteed communications in the event of a disaster. A high service availability system requires full redundancy of all elements/components on the communication path.

[0007] According to an embodiment of the present invention, a system for data transport in a Distributed Antenna System is provided. The system includes a plurality of DAUs (Digital

Access Units also referred to as Hosts) which are connected to one or more BTSs (Base Transceiver Station). In another embodiment, the BTSs can be replaced with off-air signals. The off-air signals could originate from BTSs wirelessly communicating with the DAUs or via repeaters which capture a remote signal from a BTS. The plurality of DAUs are coupled to each other and operable to transport signals between the plurality of DAUs. The system also includes a plurality of DDUs (Digital Distribution Units). Each of the plurality of DDUs are in communication with one or more of the DAUs using an optical communications path. The system further includes a plurality of transmit/receive cells. Each of the plurality of transmit/receive cells includes a plurality of DRUs (Digital Remote Units also referred to as Remote Units). Each of the DRUs in one of the plurality of transmit/receive cells is in communication with one or more of the plurality of DDUs using an optical communications path (e.g., an optical fiber, which is also referred to as an optical cable and is operable to support both digital and analog signals (i.e., RF over fiber)).

[0008] According to another embodiment of the present invention, a system for routing signals in a Distributed Antenna System (DAS) is provided. The system includes a plurality of Base Transceiver Stations (BTS), each having one or more sectors and a plurality of BTS RF connections, or Digital connections each being coupled to one of the one or more sectors. The system also includes a plurality of local Digital Distribution Units (DDUs) located at a Local location. Each of the plurality of local DDUs is operable to route signals between the plurality of local DAUs, and coupled to at least one of the plurality of remote DRUs. The system further includes a plurality of remote DDUs located at a Remote location. The plurality of remote DDUs are operable to transport signals between the plurality of remote DRUs. The plurality of local DDUs can be coupled via at least one of Ethernet cable, Optical Fiber, Microwave Line of Sight Link, Wireless Link, or Satellite Link.

[0009] The plurality of local DAUs can be connected to the plurality of remote DDUs via at least one DWDM or CWDM signal and at least one optical fiber. Similarly, the plurality of remote DDUs can be connected to the plurality of remote DRUs via at least one DWDM or CWDM signal and at least one optical fiber. The plurality of remote DDUs can be coupled via at least one of Ethernet cable, Optical Fiber, Microwave Line of Sight Link, Wireless Link, or Satellite Link. In an embodiment, the plurality of remote DDUs include one or more optical interfaces. As an example, the one or more optical interfaces can include an optical input and an optical output. In some embodiments, the system also includes a server coupled to each of the plurality of remote DDUs. A single DAU port is connected to a plurality of BTSs in some implementations.

[0010] According to another embodiment of the present invention, a system for routing signals in a DAS is provided. The system includes a plurality of local Digital Access Units (DAUs) located at a Local location. The plurality of local DAUs are coupled to each other and operable to route signals between the plurality of local DAUs. The system also includes a plurality of remote Digital Access Units (DAUs) located at a Remote location coupled to each

other and operable to transport signals between the remote DAUs and each other and a plurality of Base Transceiver Stations (BTS). The system further includes a plurality of Base Transceiver Station sector RF connections coupled to the plurality of local DAUs and operable to route signals between the plurality of local DAUs and the plurality of Base Transceiver Stations sector RF connections and a plurality of DRUs connected to a plurality of remote DAUs via at least one of a Ethernet cable, Optical Fiber, RF Cable, Microwave Line of Sight Link, Wireless Link, or Satellite Link.

[0011] According to another embodiment of the present invention, a Public Safety system for data transport in a Distributed Antenna System (DAS) includes a plurality of Digital Access Units (DAUs), Digital Distribution Units (DDUs) and Digital Remote Units (DRUs). The plurality of DAUs are coupled to each other and operable to transport digital signals between the plurality of remote DAUs. The system also includes a plurality of Digital Distribution Units. Each of the plurality of DDUs is in communication with a plurality of DAUs using an electrical communications path. The system further includes a plurality of transmit/receive cells. Each of the plurality of transmit/receive cells includes a plurality of DRUs. Each of the DRUs in one of the plurality of transmit/receive cells is in communication with one of the plurality of DDUs using an optical communications path. Redundancy of the Public Safety system is achieve by cross connecting the optical fibers amongst the plurality of DAU, DDU and DRUs.

[0012] Numerous benefits are achieved by embodiments of the present invention over conventional techniques. For instance, embodiments enable the routing redundancy at the remote location. Additionally, embodiments provide for redundancy in the context of DAS-based architectures for public safety communication systems. These and other embodiments of the invention along with many of its advantages and features are described in more detail in conjunction with the text below and attached figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a block diagram illustrating the basic structure of a digital access unit (DAU) according to an embodiment of the present invention;

[0014] FIG. 2 is a block diagram according to one embodiment of the invention showing the basic structure of a DAU with an integrated repeater functionality on the primary and secondary inputs;

[0015] FIG. 3 is a block diagram according to one embodiment of the invention showing the basic structure of an integrated DAU with repeater functionality on one of the inputs;

[0016] FIG. 4 is a block diagram according to one embodiment of the invention showing the basic structure of a digital distribution unit (DDU);

CLAIMS

1. A redundancy system for data transport in a Distributed Antenna System (DAS), the redundancy system comprising:

a plurality of Digital Access Units (DAUs) including a primary DAU and a secondary DAU, wherein each of the plurality of DAUs is fed by a plurality of data streams and is operable to transport digital signals between others of the plurality of DAUs;

a plurality of Digital Distribution Units (DDUs) including a primary DDU and a secondary DDU, the primary DDU being communicatively coupled to the primary DAU and the secondary DAU, the secondary DDU being communicatively coupled to the primary DAU and the secondary DAU; and

a plurality of Digital Remote Units (DRUs) including a primary DRU and a secondary DRU, the primary DRU being communicatively coupled to the primary DDU and the secondary DDU, the secondary DRU being communicatively coupled to the primary DDU and the secondary DDU;

a digital signal processing (DSP) unit configured to detect a failure in the DAS and redirect one or more data streams of the plurality of data streams through the DAS relative to the detected failure.

2. The redundancy system of claim 1 wherein each of the plurality of data streams comprises RF BTS signals.

3. The redundancy system of claim 1 wherein each of the plurality of DAUs includes a digital signal processing (DSP) unit.

4. The redundancy system of claim 3 wherein a DSP unit of a first DAU of the plurality of DAUs is operable to deliver a digital data signal to a DSP unit of a second DAU of the plurality of DAUs.

5. The redundancy system of claim 1 further comprising a plurality of Digital Access Units (DAUs) located at a remote location, each of the plurality of remote DAUs being

operable to receive an RF or digital input from at least one of a plurality of Base Transceiver Stations (BTSs).

6. The redundancy system of claim 1 further comprising a plurality of transmit/receive cells, each of the plurality of transmit/receive cells including a plurality of DRUs.

7. The redundancy system of claim 1 wherein the plurality of DRUs are each communicatively coupled to the plurality of DDUs using an optical communications path.

8. A Distributed Antenna System (DAS) comprising:

a primary integrated digital access unit (DAU) having a first input port, a second input port, a first output port, and a second output port;

a secondary integrated DAU having a first input port, a second input port, a first output port, and a second output port;

a connection between the primary integrated DAU and the secondary integrated DAU;

a first digital distribution unit (DDU) having:

a first input port coupled to the first output port of the primary integrated DAU;

a second input port coupled to the first output port of the secondary integrated DAU;

a first output port; and

a second output port

a second DDU having:

a first input port coupled to the second output port of the primary integrated DAU; and

a second input port coupled to the second output port of the secondary integrated DAU;

a first output port; and

a second output port;

a first digital remote unit having:

a first input port coupled to the first output port of the first DDU;

a second input port coupled to the first output port of the second DDU; and

an RF output port;

a second digital remote unit having:

a first input port coupled to the second output port of the first DDU

a second input port coupled to the second output port of the second DDU; and

an RF output port

a digital signal processing (DSP) unit configured to detect a failure in the DAS and redirect one or more data streams of the plurality of data streams through the DAS relative to the detected failure.

9. The DAS of claim 8 further comprising a first antenna coupled to the RF output port of the first digital remote unit and a second antenna coupled to the RF output port of the second digital remote unit, wherein a first coverage area associated with the first antenna substantially overlaps with a second coverage area associated with the second antenna.

10. The DAS of claim 8 wherein a primary feed received at the first input port of the primary integrated DAU is associated with a base transceiver station (BTS).

11. The DAS of claim 10 wherein a secondary feed received at the second input port of the primary integrated DAU is associated with a second BTS.

12. The DAS of claim 8 wherein a secondary feed received at the second input port of the primary integrated DAU is associated with an off-air signal source.

13. The DAS of claim 8 wherein the digital signal processing (DSP) unit is a first DSP unit positioned in the primary integrated DAU and the second integrated DAU comprises a second digital signal processing (DSP) unit, wherein a digital connection between the primary integrated DAU and the secondary integrated DAU connects the first DSP unit and the second DSP unit.

14. The DAS of claim 8 wherein the primary integrated DAU and the secondary integrated DAU are located at single main headend location.

15. The DAS of claim 8 wherein:

the first input port of the primary integrated DAU and the first input port of the secondary integrated DAU are configured to receive a primary feed; and

the second input port of the primary integrated DAU and the second input port of the secondary integrated DAU are configured to receive a secondary feed.

16. The DAS of claim 8 wherein the first input port and the second input port of the primary integrated DAU and the first input port and the second input port of the secondary integrated DAU are RF input ports.

17. The DAS of claim 8 wherein the first output port and the second output port of the primary integrated DAU and the first output port and the second output port of the secondary integrated DAU are digital optical output ports.

18. The DAS of claim 8 wherein the connection between the primary integrated DAU and the secondary integrated DAU is a digital connection.