[0003] To address these issues, Distributed Antenna Systems (DAS) have been developed and deployed. Despite the progress made in DAS, there is a need in the art for improved methods and systems related to DAS.

SUMMARY OF THE INVENTION

[0004] Embodiments of the present invention generally relate to wireless communication systems employing Distributed Antenna Systems (DAS) as part of a distributed wireless network. More specifically, embodiments of the present invention relate to a DAS utilizing software defined radio (SDR). Wireless and mobile network operators face the continuing challenge of building networks that effectively manage high data-traffic growth rates. 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 and flat-rate Internet access. Distributed Antenna Systems (DAS) provide a mechanism to route signals to various antennas that are distributed over a given geographical area. The signals typically originate from a base transceiver station (BTS), also referred to as a base station, at RF frequencies or digitally from a Baseband Unit (BBU). The BBU is part of a distributed Base Station system, whereby the Radio Unit (RU) is physically separated from the BBU. This kind of distributed architecture can increase flexibility of networking and decrease the cost of maintaining a network. Some common interface standards between the BBU and RU are OBSAI (Open Base Station Architecture Initiative), CPRI (Common Public Radio Interface) and ORI (Open Radio Interface). The cellular payload data is transported between a plurality of BBUs and RUs at a high data rate. The BBU framed data is comprised of: payload IQ data, Control and Management (C&M) information, carrier frequency, signal bandwidth, etc. A common DAS platform that interfaces between both BBUs, at baseband, and BTSs, at RF, will simplify the distributed antenna system architecture.

[0005] According to a first aspect of the present invention, there is provided a system including: a first fronthaul interface including a plurality of first digital multiplexing units (DMUs), wherein each first DMU of the plurality of first DMUs is in communication with a plurality of digital remote units (DRUs) that provide radio coverage in a given geographic location associated with the first DMU that is different from one or more geographic locations associated with other first DMUs of the plurality of first DMUs, is in communication with at least one other first DMU of the plurality of first DMUs, and is configured to: receive a plurality of first signals from a first baseband unit (BBU) and from one or more other first DMUs of the plurality of first DMUs; extract a first subset of the plurality of first signals associated with the plurality of DRUs associated with the first DMU; aggregate the first subset of the plurality of first signals into a first stream; and route the first stream to one or more DRUs of the plurality of DRUs.

[0005a] According to a second aspect of the present invention, there is provided a system including: a first fronthaul interface including a plurality of first digital multiplexing units

(DMUs), wherein each first DMU of the plurality of first DMUs is in communication with a plurality of digital remote units (DRUs) that provide radio coverage in a given geographic location associated with the first DMU that is different from one or more geographic locations associated with other first DMUs of the plurality of first DMUs, is in communication with at least one other first DMU of the plurality of first DMUs, and is configured to: receive a plurality of first signals from a first baseband unit (BBU) and from one or more other first DMUs of the plurality of first DMUs; extract a first subset of the plurality of first signals associated with the plurality of DRUs associated with the first DMU; aggregate the first subset of the plurality of first signals into a first stream; and route the first stream to one or more DRUs of the plurality of DRUs.

[0006] According to a third aspect of the present invention, there is provided a system including: a fronthaul interface including a plurality of first digital multiplexing units (DMUs), wherein each first DMU of the plurality of first DMUs is in communication with a plurality of digital remote units (DRUs) that provide radio coverage in a given geographic location associated with the first DMU that is different from one or more geographic locations associated with other first DMUs of the plurality of first DMUs and is in communication with at least one other first DMU of the plurality of first DMUs, and a first DMU of the plurality of first DMU is configured to: receive a plurality of signals from a baseband unit (BBU) and from one or more other first DMUs of the plurality of first DMUs; extract a first subset of the plurality of signals associated with a plurality of DRUs; aggregate the first subset of the plurality of signals into a stream; and route the stream to one or more DRUs of the plurality of DRUs via a second DMU.

[0007] Disclosed herein is a system for routing signals in a Distributed Antenna System (DAS). The system includes one or more Base Band Units (BBUs). Each of the one or more BBUs has one or more digital outputs. The system also includes a plurality of Digital Multiplexer Units (DMUs) coupled to each other and operable to route signals between the plurality of DMUs. Each of the plurality of DMUs is operable to receive one or more digital inputs from the one or more BBUs. The system further includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DMUs and operable to transport signals between the plurality of DRUs and one or more of the plurality of DMUs.

[0008] Disclosed herein is a method for routing signals in a Distributed Antenna System (DAS) including a plurality of Digital Multiplexer Units (DMUs) and a plurality of Digital Remote Units (DRUs). The method includes receiving, at ports of the plurality of DMUs, digital signals from sector ports of one or more Base Band Units (BBUs). The method also includes routing the digital signals between the plurality of DMUs and transporting the digital signals between the plurality of DMUs and a plurality of DRUs.

[0009] Disclosed herein is a Distributed Antenna System (DAS). The DAS includes a plurality of Digital Multiplexer Units (DMUs) coupled to each other and operable to route signals between the plurality of DMUs. Each of the plurality of DMUs includes a plurality of

digital input ports operable to receive digital inputs from one of more of a plurality of BBUs. Each of the plurality of BBUs includes a plurality of digital output ports. The DAS also includes a plurality of Digital Access Units (DAUs) coupled to each other and operable to route signals between the plurality of DAUs. Each of the plurality of DAUs includes a plurality of analog input ports operable to receive analog RF inputs from one of more of a plurality of BTSs. Each of the plurality of BTSs includes a plurality of analog RF output ports. The DAS further includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DMUs and operable to transport signals between DRUs and DMUs, each of the plurality of DRUs including a remote antenna.

[0010] Disclosed herein is a system for routing signals in a Distributed Antenna System. The system includes a plurality of Digital Multiplexer Units (DMUs). The plurality of DMUs are coupled and operable to route signals between the plurality of DMUs. The system also includes a plurality of Digital Remote Units (DRUs) coupled to the plurality of DMUs and operable to transport signals between DRUs and DMUs, a plurality of Base Band Units (BBU) with digital connections to the plurality of DMUs and operable to route signals between the plurality of DMUs and the plurality of digital connections.

[0011] Disclosed herein is a system comprising a core network, a data center in communication with the core network, and a plurality of digital remote units (DRUs) in communication with the data center. The data center comprises a plurality of baseband units (BBUs) and a plurality of digital multiplexing units (DMUs). The plurality of DMUs are configured to route I/Q data to one or more of the plurality of DRUs. Control and management (C&M) functionality of each DMU and DRU is located in a cloud network.

[0012] Numerous benefits are achieved embodiments the present invention over conventional techniques. For example, embodiments of the present invention provide methods and systems that utilize system elements with reduced hardware requirements (e.g., radio units in BTSs and radio units in DAUs), thereby reducing system cost, reducing system power consumption, and reducing system size. Additionally, embodiments described herein reduce or remove the requirement to perform RF to digital conversion and digital to RF conversion, thereby reducing signal degradation. 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] Further embodiments and advantages of the present invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[0014] FIG. 1 is a block diagram according to one embodiment of the invention showing the basic structure and an example of the transport routing based on having a single 3 sector BBU with 3 DMUs and 7 DRUs daisy chained together for each cell.