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High-accuracy latency measurement to support radio beamforming for 5G applications

Florian Azendorf[1], Bernhard Schmauss[2], Michael Eiselt[1]

[1] ADVA Optical Networking SE, 98617 Meiningen, Germany
[2] LHFT, Friedrich-Alexander Universität Erlangen-Nürnberg, 91058 Erlangen, Germany
fazendorf@advaoptical.com

The envisioned 5G capabilities for providing advanced content to the end users set strict requirements for increased capacity and flexibility in the use of resources. The European project BlueSpace addresses these applications by the introduction of spatial division multiplexing (SDM) in the Radio Access Network (RAN) segment. Analog Radio over Fiber (ARoF) and Digital RoF (DRoF) are investigated to transmit the radio baseband signal between the base band unit (BBU) and the remote radio unit (RRU). While DRoF solutions are commercially available already for LTE, mostly using a data format according to the standard Common Public Radio Interface (CPRI) specification, ARoF can provide a much higher capacity and allows the centralization of all processing functions, potentially including the beamforming network, in the BBU. The analog radio baseband signal is generated at the Central Office (CO) and transmitted via optical fiber to the RRU, where the signal is upconverted to the radio spectrum and sent via the antenna. This enables a simplification of the RRU. A further step to increase flexibility is achieved by introducing optical Multiple Input Multiple Output (MIMO) technologies for advanced beam steering techniques. The use of beamforming at the RRU is essential for operations at 26 GHz, but the control of these beams adds complexity. Placing the generation of the phase coupled radio signals for each phase array element into the BBU enables centralized processing but requires a highly synchronous transmission between the BBU and the RRU. The allowed phase error of 30 degrees between the antenna elements corresponds to a maximum allowed latency difference of 3.2 ps [1]. While multi-core fibers are a contender for the transmission link, the latency differences between the cores must still be measured upon installation and might need to be monitored during operation. One well-known method to monitor the optical fiber from one side is Optical Time Domain Reflectometry (OTDR). The resolution of an OTDR is limited by the pulse width of the probe pulse and the power of this pulse. To improve the resolution of an OTDR we use a correlation between probe data sequences, known as Correlation-OTDR (C-OTDR). By applying additional signal processing to the correlation signal, we achieve a high accuracy of the measured fiber latency on the order of a few picoseconds. In this presentation we will give an overview of the principle of the C-OTDR [2] and show some measurement results. Also we will discuss the influence of environmental conditions such as temperature on the latency of different fibers.

References

[1] https://www.zenodo.org/record/1402052#.W7xW1WgzY2w
[2] M.Eiselt and A.Dochhan, “Single-Ended Fiber Latency Measurement with Picosecond-Accuracy Using Correlation OTDR.” Paper 5C1-3 Proc. 23st OptoElectronics and Communication Conference (OECC), Jeju, Korea, July 2018