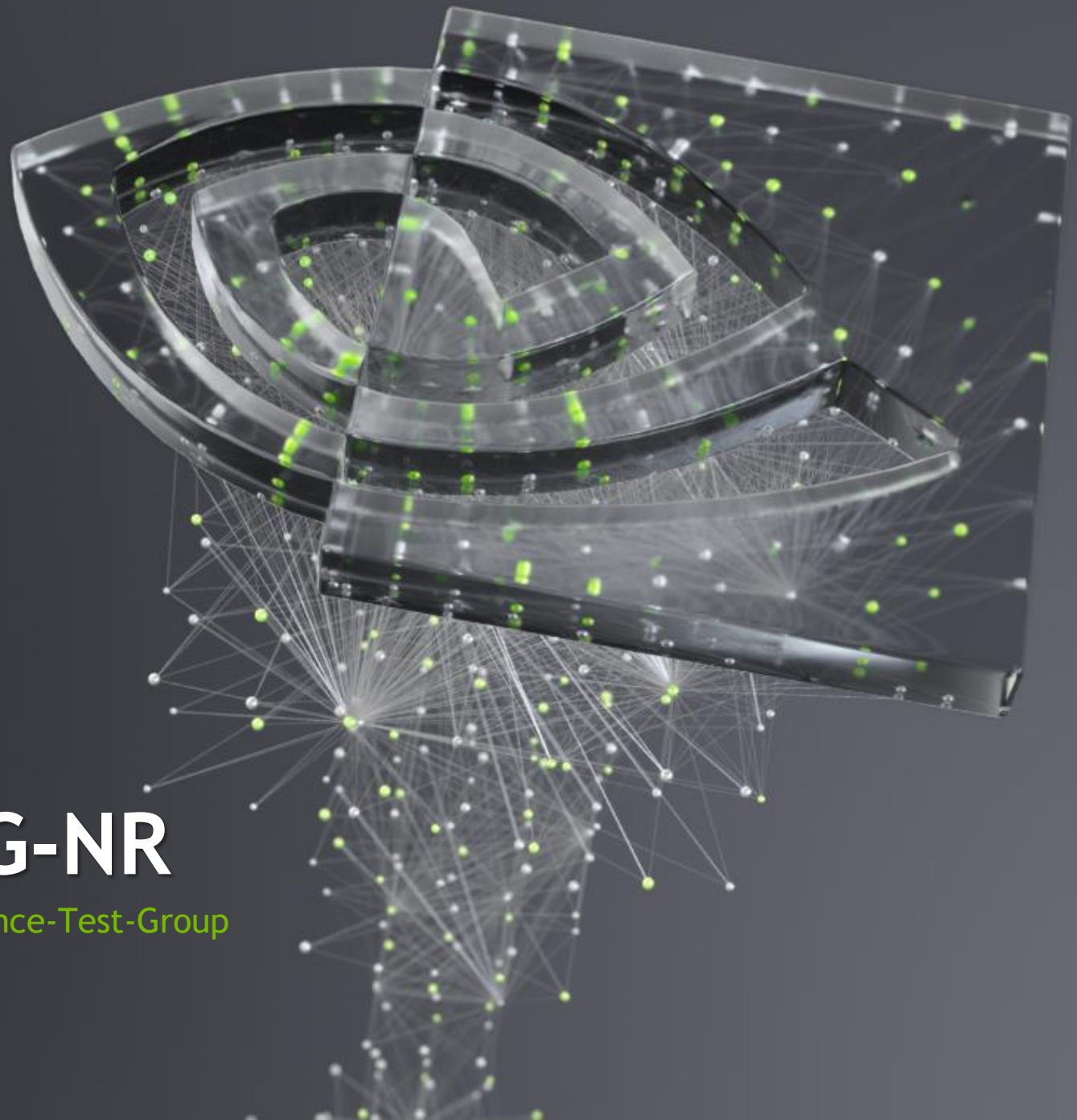

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OVERVIEW OF BEAMFORMING IN 5G-NR

2021-04-06 Presentation to O-RAN WG04-Conformance-Test-Group

OBJECTIVES

Overview of Beamforming in 5G-NR

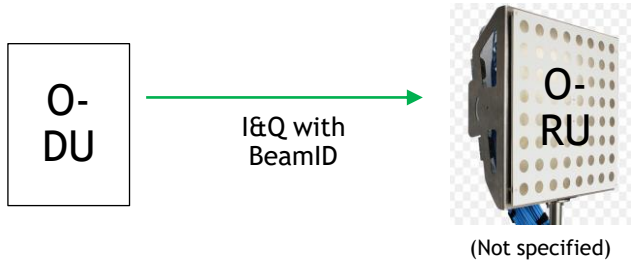
- Highlight interfaces between the O-DU and the O-RU in beamforming in the context of the O-RAN fronthaul C/U/S-plane conformance testing

- Focus on O-RAN and related 3GPP material only (content has no relation to products or product plans)

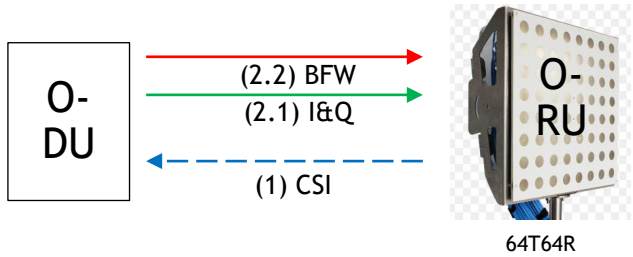
5G NR BEAMFORMING

DL Beamforming (BF) Considered Only

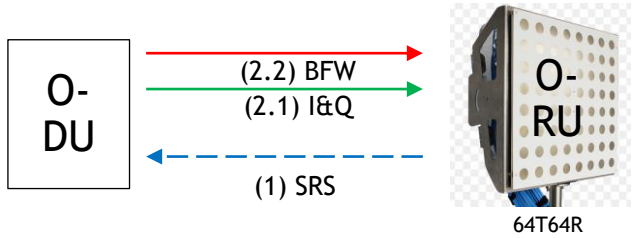
- Analog Beamforming
  - Use case: O-RAN BF Method1



- Digital Codebook-based Beamforming
  - Use case: O-RAN BF Method2 and Method4



- Digital Reciprocity-based Beamforming (TDD)
  - Use case: O-RAN BF Method2 and Method4

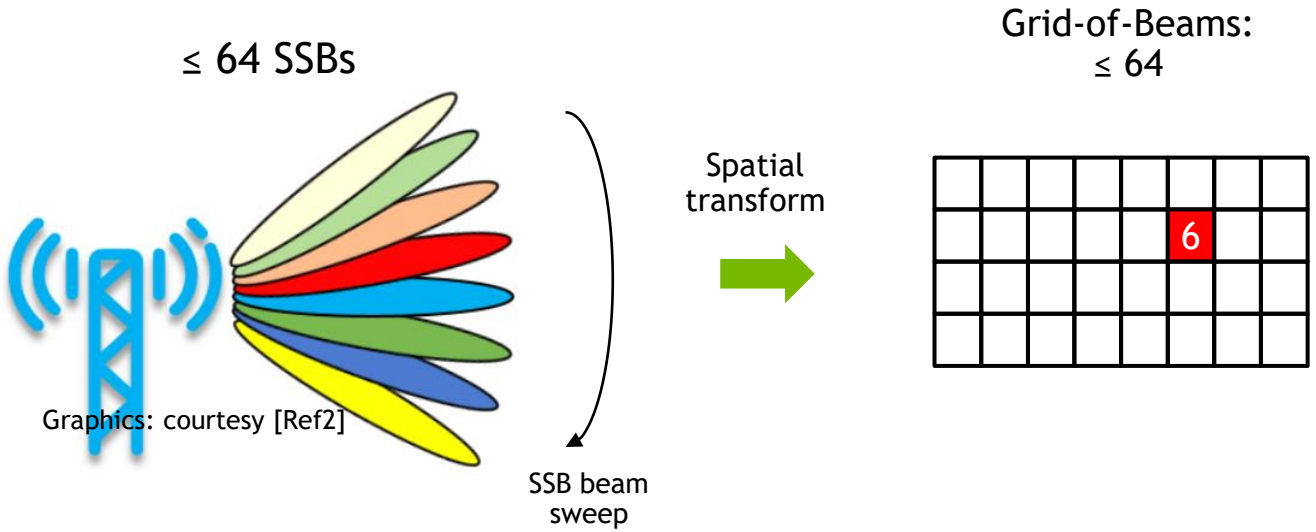


- (Others exist, e.g., O-RAN BF Method3 [Ref1], but are not described here)

ANALOG BEAMFORMING

Use Case: e.g., O-RAN Beamforming Method 1

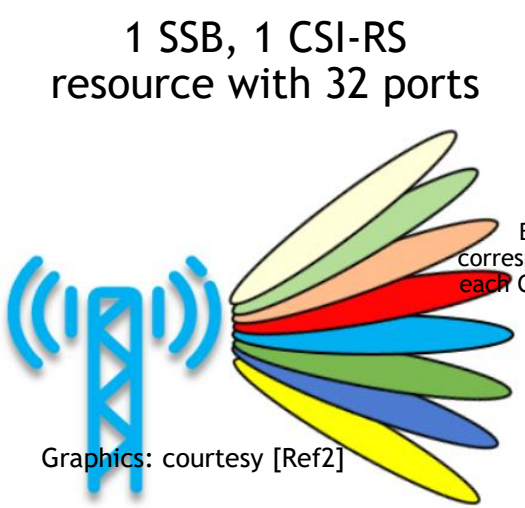
- O-RAN BF Method 1 [Ref1] (Predefined-beam BF)
  - Antenna array with many antenna elements
  - UE I&Q data by the BeamID transferred from O-DU to O-RU labeled each TTI
  - At the O-RU, BF by applying common phase-shifts
- Predefined (up to) 64 SSB, time-domain, beams by Grid-of-Beams
- UE sweeps and tracks the strongest beam, through Beam Management
  - P2 & P3 CSI-RS based refinement not shown

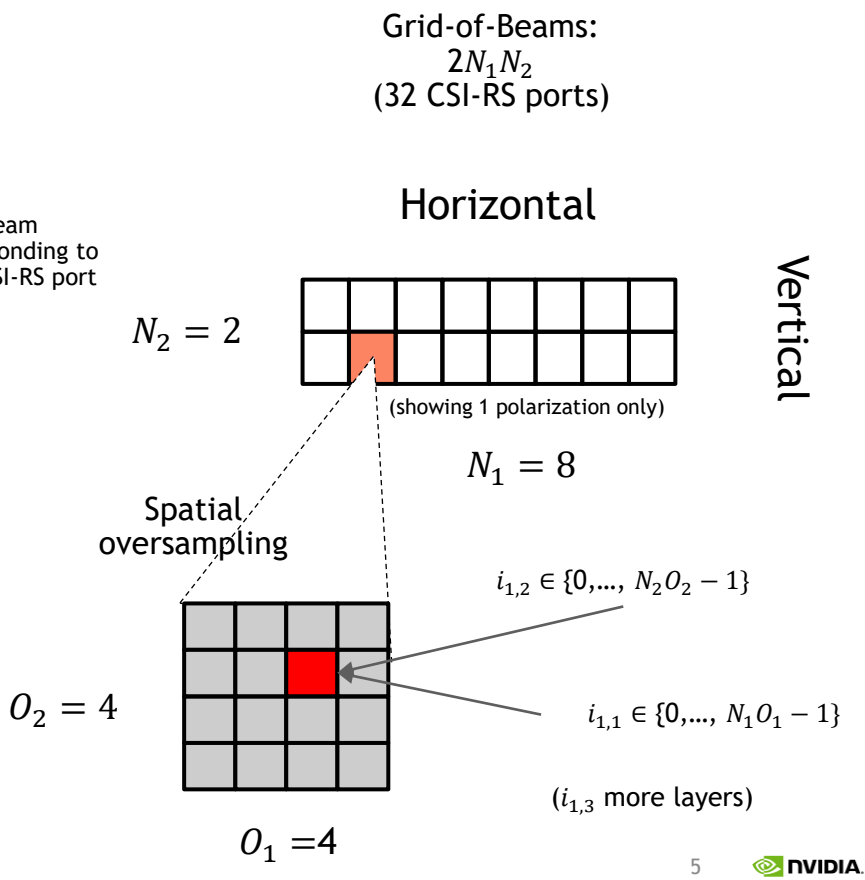


CODEBOOK BASED BEAMFORMING

Use Case: e.g., O-RAN Beamforming Method2 and Method4

- O-RAN BF Method 2 [Ref1] (Weight-based BF)
  - Use case: a 64T64R antenna array
  - 1 (or more) SSB, to 1 (or more) CSI-RS resource(s) with ≤ 32 ports in freq-time
  - BFW and UE I&Q data transferred to the O-RU that applies BFW to ≤ 16 layers of I&Q
- *(For O-RAN BF Method4, channel info transferred instead)*
- UE feeds back PMI $(i_{1,1}, i_{1,2})$ in CSI-RS port Grid-of-Beams [Ref3] and $i_{1,3}$ for >1 layers
- PMI BF weights adopted by O-DU into a 64x16 (max) BF matrix for SU- or MU-MIMO

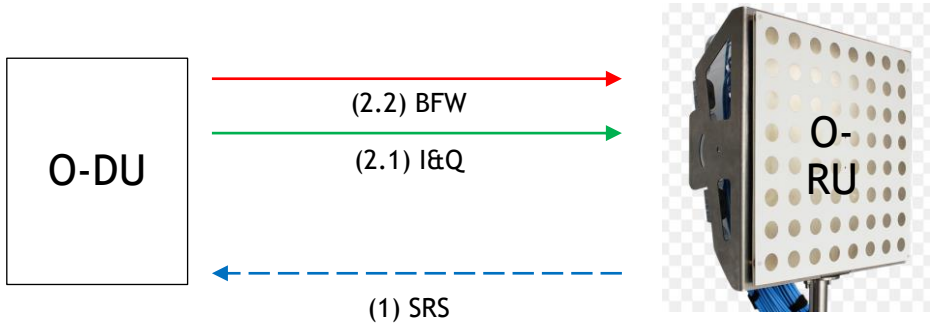




RECIPROCITY BASED BEAMFORMING

Use Case: e.g., O-RAN Beamforming Method2 and Method4

- O-RAN BF Method 2 [Ref1] (Weight-based BF)
  - Assuming channel reciprocity, i.e., TDD
  - 64x16 BF weights and UE I&Q data transferred to O-RU that applies BFW to ≤ 16 layers of I&Q
- *(For O-RAN BF Method4, channel info transferred instead)*
- O-DU performs channel estimation from UL SRS to obtain UE 64x1 (min) channel vectors
  - CSI-RS may still be used for UE CQI (i.e., without PMI) for link adaptation
- UEs whose channel vectors, i.e., ≤16, form an orthogonal set are co-scheduled by O-DU for MU-MIMO



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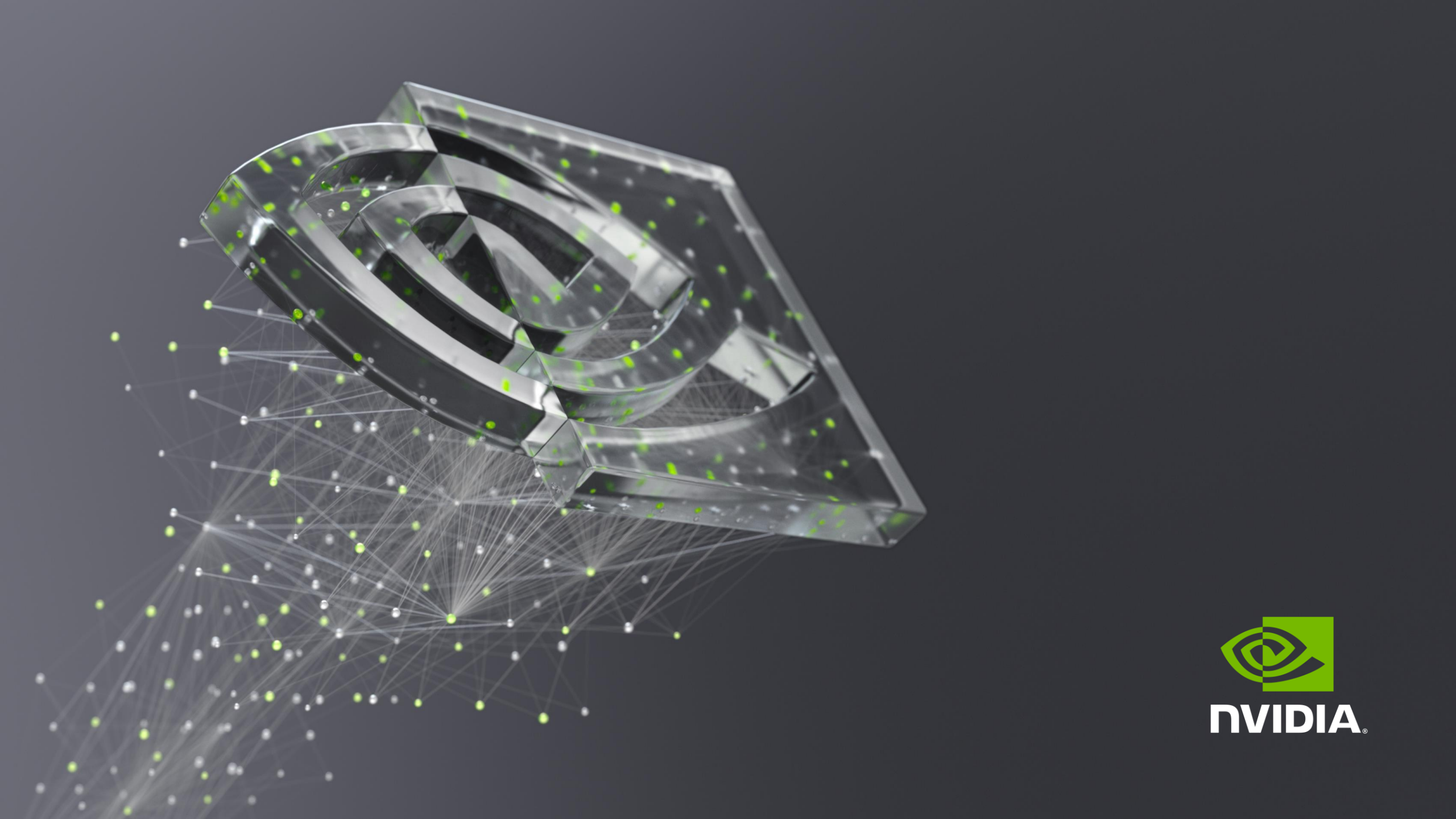
- [1] O-RAN.WG4.CUS.0-v05.00.03, O-RAN Fronthaul Working Group Control, User and Synchronization Plane Specification
- [2] 5G New Radio: Unveilingthe Essentials of the Next Generation Wireless Access Technology, by X. Lin, J. Li, R. Baldemair, T. Cheng, S. Parkvall, D. Larsson, et al. https://arxiv.org/ftp/arxiv/papers/1806/1806.06898.pdf
- [3] 3GPP TS38.214, https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3216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