ICN- From Streaming to Metaverse

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Background

- ICN proposed as an architecture to deliver content object without binding the content objects to a specific servers
  - “turbocharged” content delivery
- Main Internet content is video streaming
  - North of 80% of all Internet traffic
- RFC7933
  - Adaptive Video Streaming over Information-Centric Networking (ICN)
  - Considers how to adapt video streaming for ICN and ICN for video streaming
- Metaverse?
  - How does it relate to streaming?

Metaverse: Definition

- Def 1: “an integrated immersive ecosystem where the barriers between the virtual and real worlds are seamless to users, allowing the use of avatars and holograms to work, interact and socialize with simulated shared experience” (Meta 2022)
- Def 2: “a 3D virtual shared world where all activities can be carried out with the help of augmented and virtual reality services” (Damar 2021)
- Def 3: “the next generation Internet that is always real-time and mostly 3d, mostly interactive, mostly social and mostly persistent” (John Ricobello)

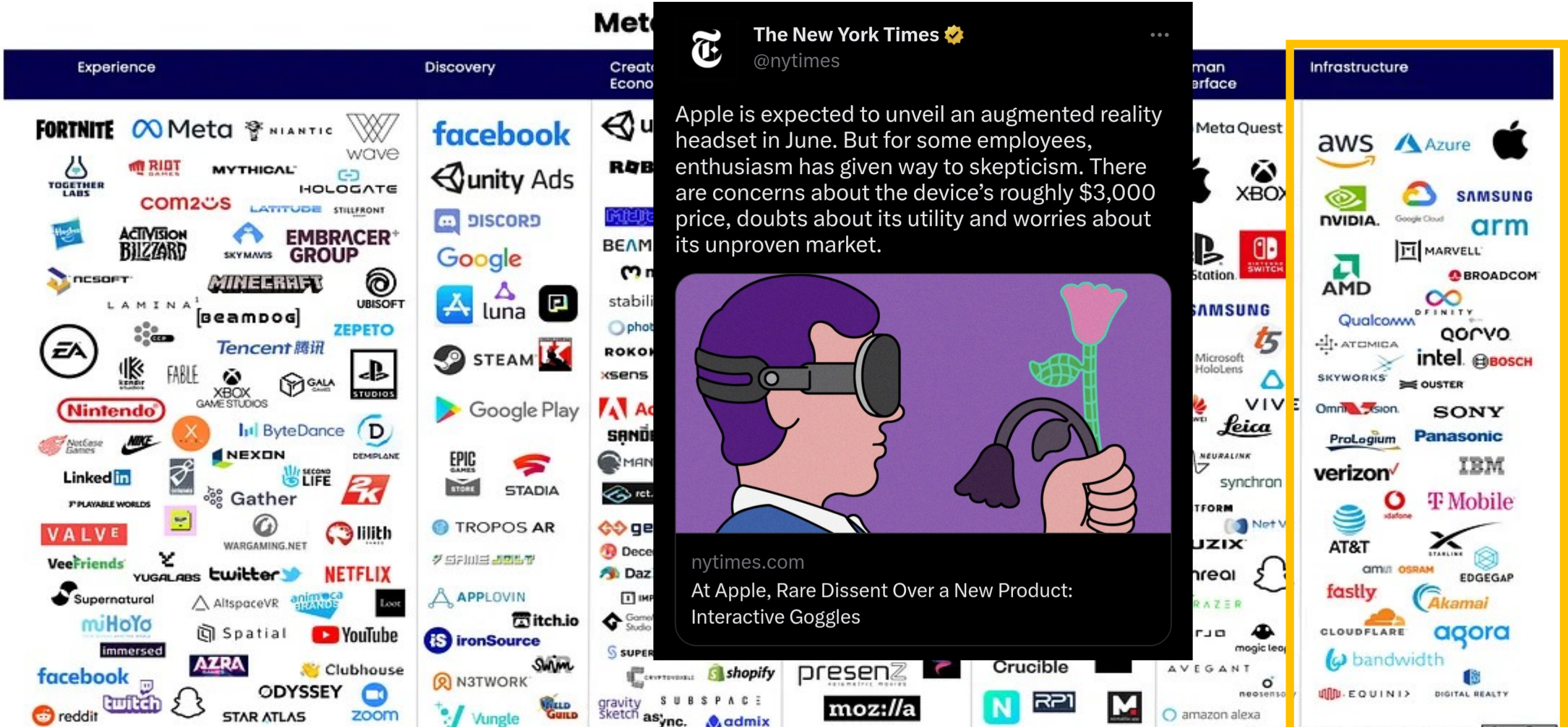
Metaverse: Taxonomy

- From “Metaverse beyond the Hype” (Dwivedi et al, 2022)
- Environment
  - Realistic, unrealistic, fused
- Interface
  - 3D, immersive, physical methods
- Interaction
  - Social networking, collaboration,
- Security
  - Data security, privacy, software/hardware/network security

- Different instantiations with different property along these dimensions
- Adding: Centralized/Distributed?

Metaverse: Ecosystem

- From Jon Radoff “How to build a metaverse”



Inheritances & Dependencies

Streaming

Video Conferencing

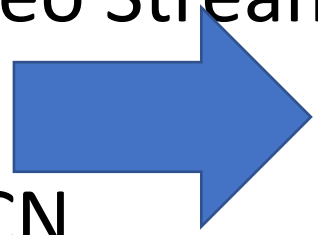
Social Network

Metaverse

Key issues for video streaming in ICN?

From RFC7933:

- Video Streaming and ICN
  - Client-Driven Streaming and DASH / Layered Encoding
  - Interactions of Video Streaming w/ ICN
  - Possible Integration of Video Streaming and ICN
- P2P Video Distribution and ICN
- IPTV and ICN
- Digital Rights Management in ICN



Metaverse mapping:

Streaming metaverse views
- with what encodings?

- How to interact w/ ICN
- How to integrate w/ICN

- Distributed content
- Multipath/multicast?
- ACL, owner, authentication?

Metaverse & ICN?

- From the infrastructure perspective, the metaverse would be a distributed system that shares content in real time on a massive global scale with QoE requirements for users in a secure way with complex ownership/access privileges
- Massive content distribution of objects with their own security and access policy? Did I hear you say ICN?

- Consider to adapt ICN for metaverse, and Metaverse for ICN?

Metaverse & ICN: Objects

- Content objects to render a metaverse environment
- Within that environment, “virtual physical” objects
  - Objects/avatars for the users within the virtual world
    - Persistence of objects left within the metaverse by users?
    - Access right: who sees what? Who can see, use, modify, remove? (rwxrwxrwx?)
  - Collection of objects associated with a specific space
    - FLIC/Manifests
- Ownership
  - Platform owns the virtual environment
  - Users owns object within the platform
  - Intellectual property: who owns what is generated within the platform
  - How to represent these different levels of ownership, authentication, access control within the definition of an object?

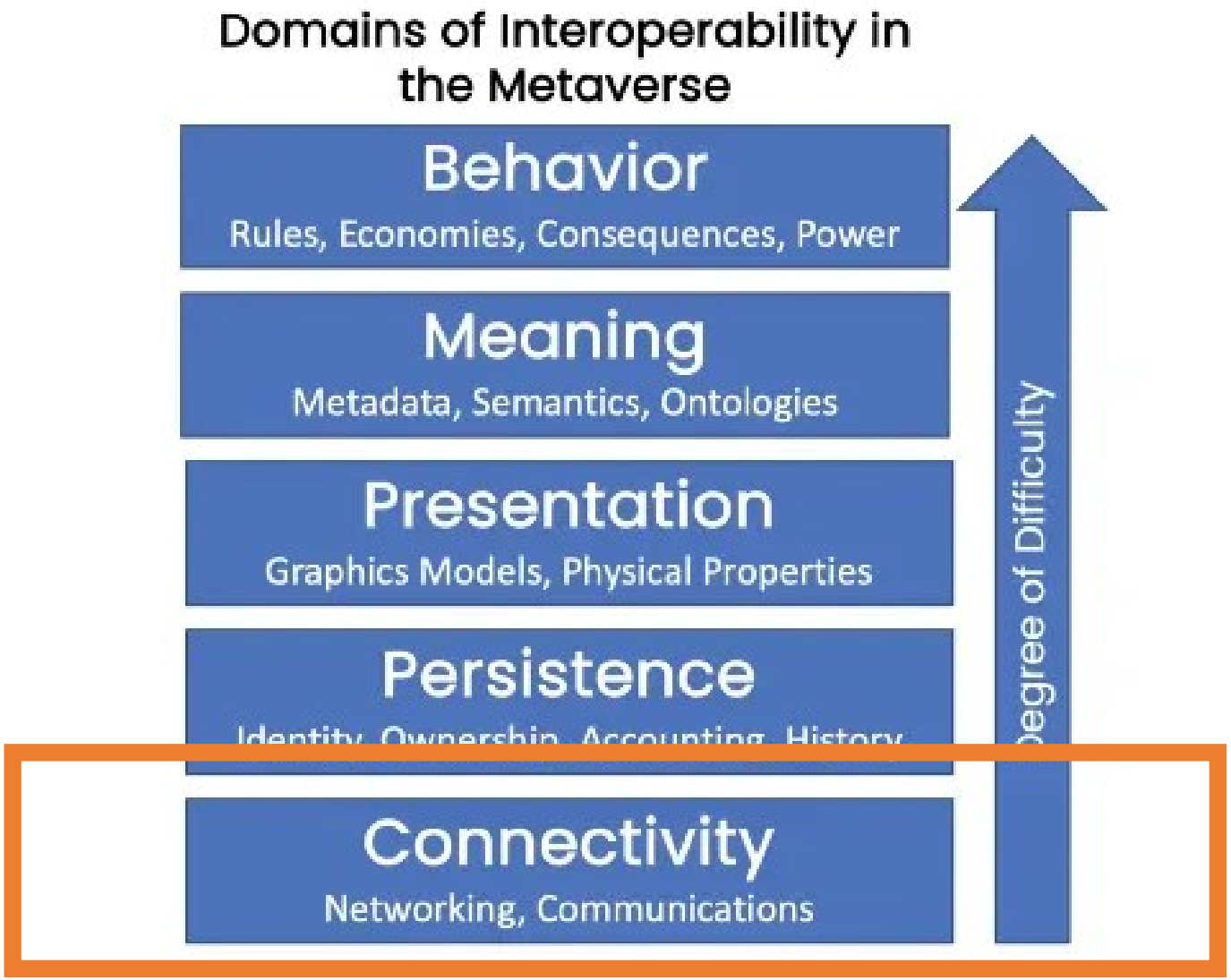
Metaverse & ICN: Decentralization

- One of the dimensions of the taxonomy
- Meta vs Decentraland;
- App overlay or embedded within network?

- Hierarchical structure imposed for scalability considerations
  - But can the edge run independently?
  - Can a metaverse runs disconnected from a central authority?
- ICN decouples the objects from the origin server
  - A step into the right direction
  - Can the operation of the metaverse be decoupled as well?
    - NFN?

Metaverse: Interoperability

- From Jon Radoff “How to build a metaverse”



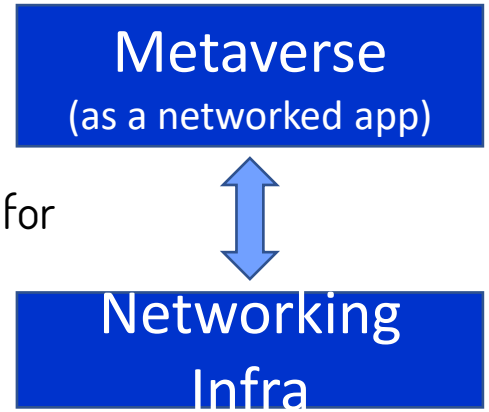
How to provide a common framewrok?

What are the research challenges for the Metaverse in ICN?

- Interoperability
- Scalability
- Privacy/Security
- Low-latency
  - Cf. “Networking at the speed of light” project
  - Or via LEO Satellites
- Machine learning for behaviors within the metaverse
  - Predictability of immersive video streaming (say, FoV) applies to Metaverse
- Programmability to support application requirements?
  - COIN as the new architecture opportunity?
- High Precision of the traffic
- What models are needed to evaluate research proposals?
- Sustainability? Green networking?

Metaverse opportunity for network providers

- What opportunities does metaverse offer network providers?
  - Aspect 1: Another application that drives traffic
    - Compare Social Media, Video Streaming, Zoom
    - But: spoils of earlier applications went to the app providers, not network providers
  - Aspect 2: Where do required network services go beyond vanilla?
    - What Metaverse features would those unlock that users would be willing to pay extra for
- Examples
  - Real-time digital and metaverse twins
    - The same objects and actors interact simultaneously across multiple universes
    - Requires very precise timing for massive amounts of synchronization data
  - Haptic and tactile applications in the AR metaverse
    - Illusion of touch only maintained with msec round-trip latencies
  - Holographic avatars and landscapes
    - Massive data volumes require dynamic stream adaptation to adapt to changes in focus and viewpoint
    - Msec latencies required even for “non-live” content



Credit: Alex Clemm

What are the ICN research challenges for the Metaverse?

- For you to define and solve!

- Is this worth exploring in a RFC7933 for the metaverse?
  - Draft in progress, missed cut off, will email to list after IETF

- Questions?