# Insights into deploying Private 5G and outlook to making 6G happen

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# Norwaves Strategic Direction

Deploy Commercial Ready
5G / 5.5G Private Networks

Keep advancing through
6G *(ex:EU Research projects)*

# Private 5G – All About “Critical Services”

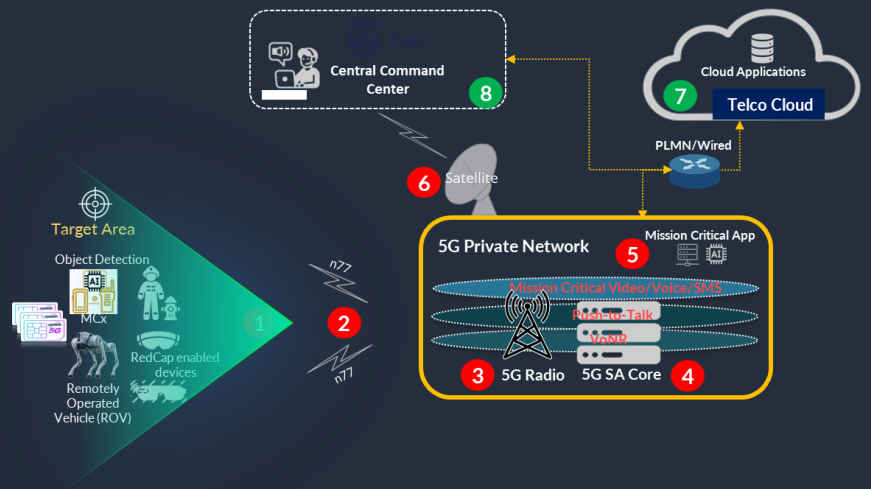
# Oslo Kommune

- **Outdoor and indoor trials of Mission Critical Services over a Private 5G Network for Oslo Municipality, conducted on 17th May as part of the 'Krisekommunikasjon 5G – KRIKOM5G' project.**

- **5G Use Cases:**

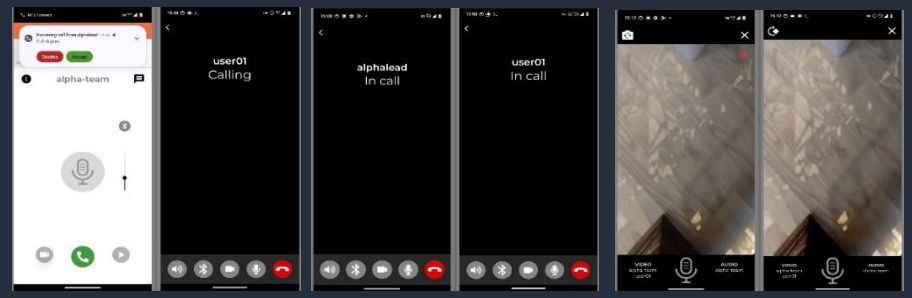
| | | | |
|---|---|---|---|
| Rapidly deployable standalone 5G | Resilient 5G and interreference free network | Mission Critical Voice/Video/group communication | Outdoor & Indoor Scenarios |

- **Delivered using a standalone Private 5G network with dedicated spectrum acquired from NKOM on behalf of Oslo Municipality.**

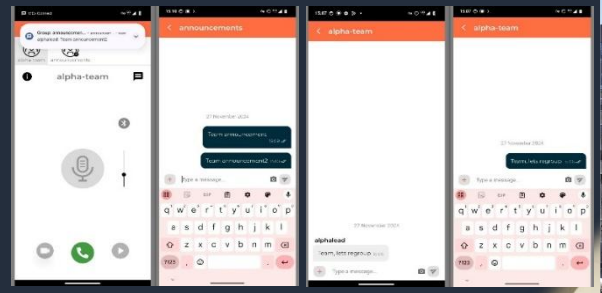



MCX Voice Communication

MCX Video




Group Communication




5G LINK PERFORMANCE ANALYS

Kongsberg Maritime

# Maritime

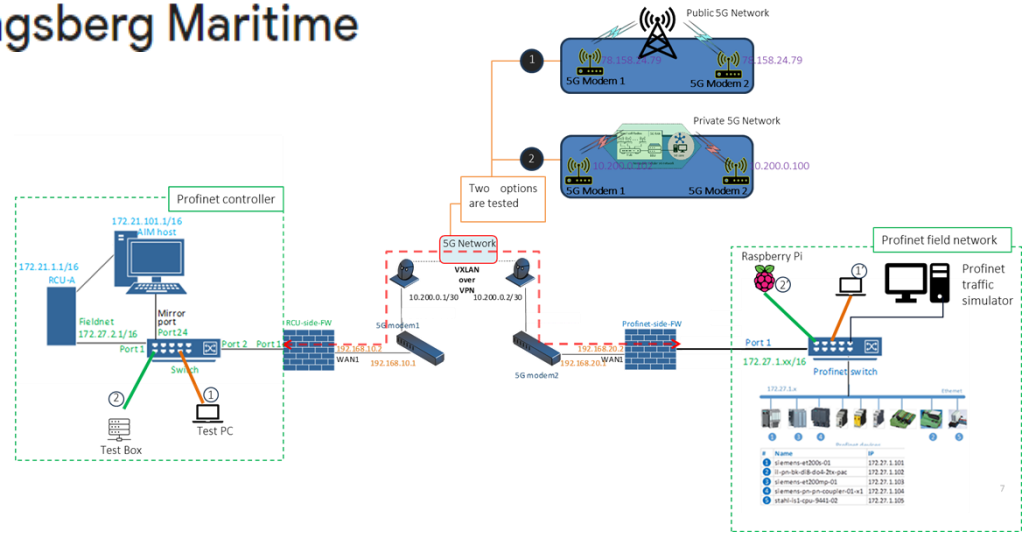
- **Deployed Private 5G Network as part of the European Commission Project "FIDAL" at Kongsberg Maritime Headquarters, Kongsberg , Since May.2024**

- **5G Use Cases:**

| | | | |
|---|---|---|---|
| Ship Onboard communications (uRLLC/mMTC) | Connecting Layer 2 devices natively to 5G network | UE-UE communication | Data aggregation UseCase |

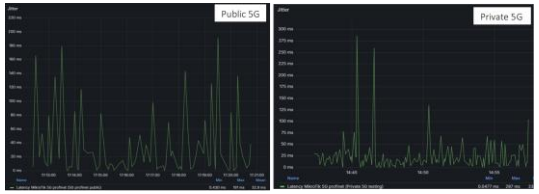
- **Delivered using a Standalone Private 5G Network with Kongsberg Maritime's dedicated Private 5G Spectrum**

Kongsberg Maritime

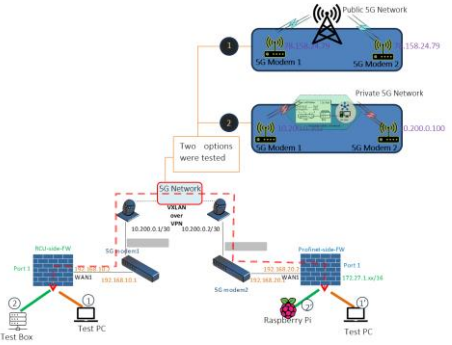



5G PERFORMANCE IN PROFINET FIELD NETWORK

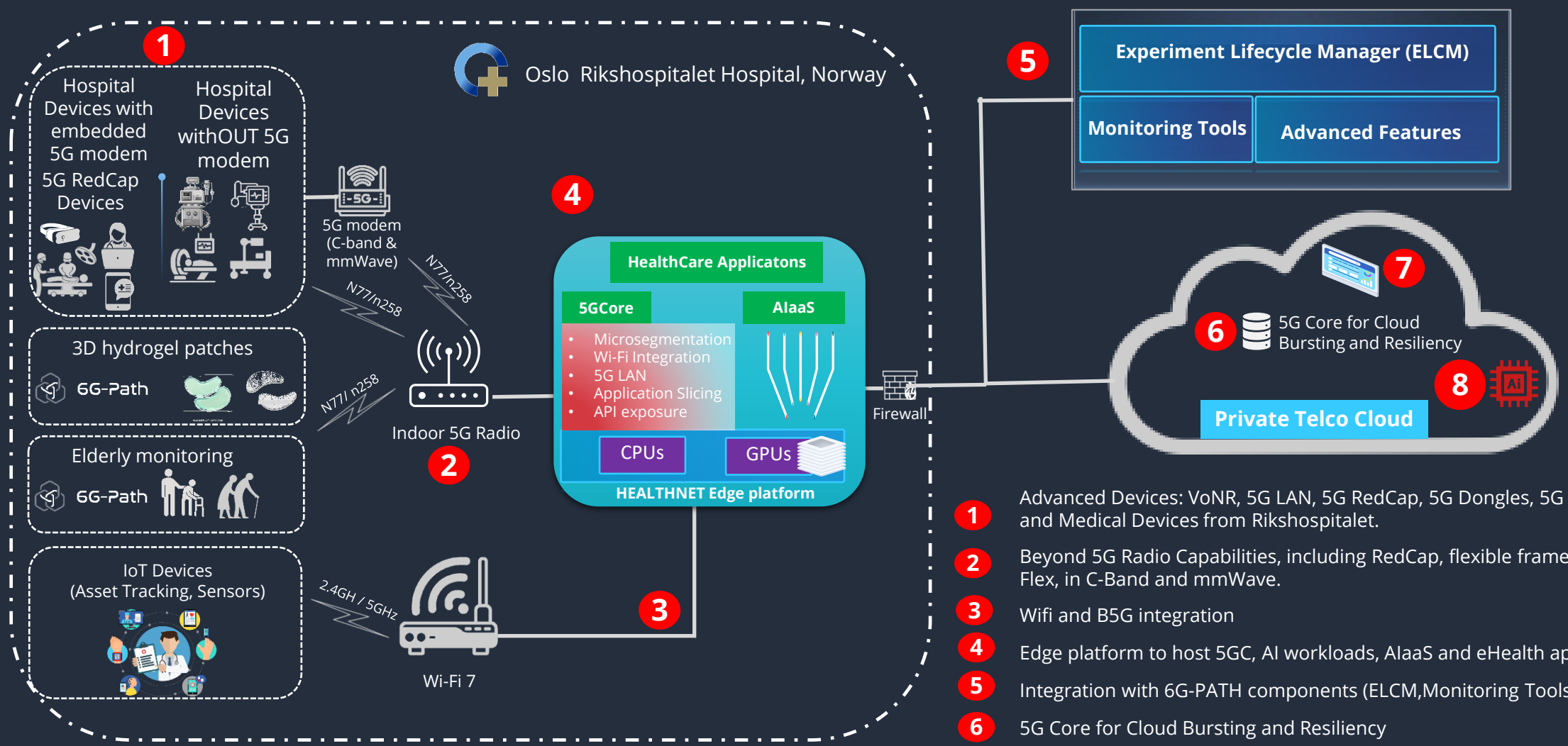
PUBLIC 5G VS PRIVATE 5G TESTS




5G LINK PERFORMANCE ANALYSES



# Public Health




1. Advanced Devices: VoNR, 5G LAN, 5G RedCap, 5G Dongles, 5G CPE, AR/VR Headsets, and Medical Devices from Rikshospitalet.
2. Beyond 5G Radio Capabilities, including RedCap, flexible frame structure, and NG-Flex, in C-Band and mmWave.
3. Wifi and B5G integration
4. Edge platform to host 5GC, AI workloads, AIaaS and eHealth applications
5. Integration with 6G-PATH components (ELCM,Monitoring Tools,Advanced Features)
6. 5G Core for Cloud Bursting and Resiliency
7. Unified Management Platform to manage B5G Radios,Core, and devices
8. AI Training

***Note**: This reflects a broader scope, while the current setup and use cases are at different stages of development and continuing to evolve.*

# Capabilities

# Atomic Capabilities to Customize for Verticals and Scale...

Available

Roadmap

Atomic Capabilities

1. Data Local Breakout (UPF)
2. Mission Critical Services (MCX)
3. Slicing / Quality Of Service (QOS)
4. AI for Industry (AI Apps)
5. 5G & Wi-Fi Integration
6. Telco Cloud/ Edge Computing
7. Industrial AR/VR Applications
8. Flexible Uplink/Downlink Speeds
9. 5G LAN, Ethernet PDU,TSN
10. Native 5G Voice & SMS (VoNR, SMS)
11. Positioning
12. RedCap/ eRedCap
13. Ambient IoT (Passive-IoT)
14. TN-NTN Integration (Satellite)

## Enable Various Industries

### Hospital

Use Cases: 3 4 5 6 7 11

- *AR-assisted surgeries*
- *AI-driven medical imaging*
- *IoT-based ward monitoring*

### Maritime

Use Cases: 2 6 7 9 12

- *Ship/platform-to-shore Com*
- *Ship/platform-to-ship Com*

### Defense

Use Cases: 2 3 7 9 11 14

- *Command Control System*
- *Multicast-Broadcast*

### Media Broadcasting

Use Cases: 1 3 7 8

- *Remote 4K Video broadcast*
- *5G Network-in-Box with backhaul*

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# Embodied in Norwaves 5G Network in a Box (NIB)

**Norwaves 5G Network in a Box (NIB)** – a plug-and-play, all-in-one solution for rapid 5G deployment. Packed into a compact briefcase, it comes pre-integrated with a fully functional, high-performance 5G Radio Access Network (RAN), 5G Standalone (SA) Core, and 5G SIM-equipped devices, enabling swift, seamless, and hassle-free 5G network setup.

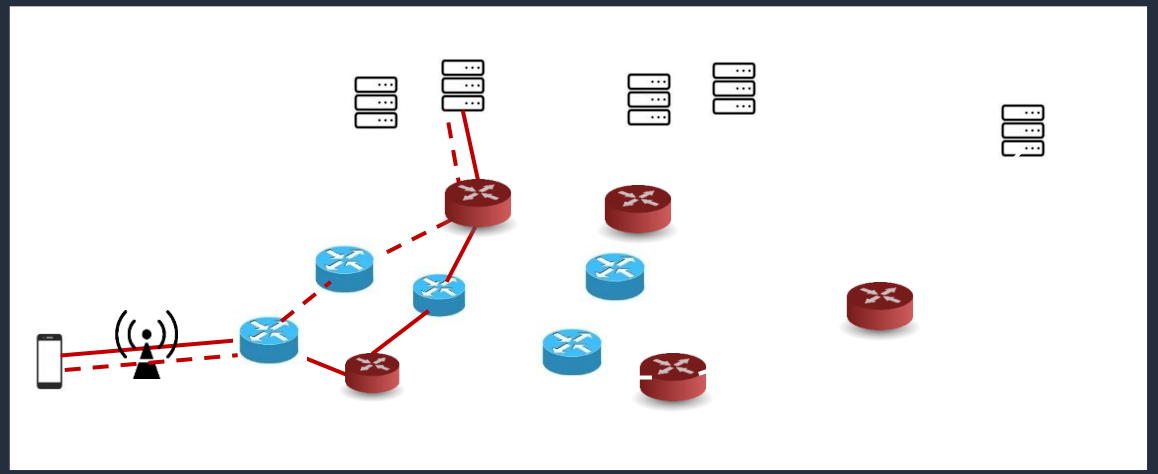
- **3GPP Rel15/16** – 5G Radio, 5G Core
- **Low Latency**
- **High Speeds**
- **Plug & Play**
- **Norway Private Spectrum Band** – n77,n78
- **Cloud Platform** – Oracle Cloud Platform, aws
- **GUI Interface**
- **Pre-Integrated UCs**
- **Transmit Power** – 250mW / 5W
- **Devices & 5G SIMs**

# Gaps – to be Covered by 6G?

# Routing on Service Addresses (ROSA)

- DNS maps service addresses, e.g., URIs onto IP addresses
  - Even local DNS incurs about 10 to 15ms latency for every lookup
  - Changes in name->address assignment can only change longer-term
    -> counter the idea of edge computing and several virtualised service instances
    -> fallback to edge orchestration, which comes with complexity & latency challenges itself
  - Increasing dependency on non-EU players (Google, CloudFlare, Amazon, ...)

- Enter ROSA
  - Piggyback name resolution on first IP data packet exchange (usually a TLS handshake)
  - Route first packet over ROSA overlay, which forwards based on name entries
    - Make pathfinding decision based on ingress scheduling or overlay routing
  - Route subsequent packets directly over IPv6 after first packet was delivered to target IP
  - Redo assignment at every flow start (e.g., TCP/QUIC connection)



# Routing on Service Addresses (ROSA)

**Capabilities**

- No resolution latency (overlay routing can be almost as flat as direct IPv6)
- MUCH faster path finding than name resolution (since core overlay router can handle >100k packets per second)
- Largely backwards compatible – requires using user space library at endpoints (similar to QUIC)

**Scenarios**

- *Smoother video streaming*: replicate video at N instances, schedule each chunk request to instance in weighted fair scheduling (weight is proportional to instance processing power)
  -> 30% reduced jitter, about 40% more users per server being served below latency boundary (IFIP Networking 2022)
- *Faster web browing*: place ingress overlay router at CDN ingress, place short tail of web objects into ROSA name space, rest via DNS
  -> up to 60% faster page loading times, depending on ROSA object proportion
- *Carbon-negative AI*: place edge AI servers at renewable energy source, activated ONLY on surplus energy, route to edge servers only when active
  -> target is carbon-negative AI processing (still to be shown)

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# Flexible core federation

- Private 5G is not just about localised processing and communication
- Private 5G is not just about interconnection via Internet
- Next Generation of P5G will be about building flexible federations of localised entities
  - *Single patient network*, consisting of hospital P5G, ambulance Network-on-Wheel, and patient home
  - *Single industrial network*, consisting of factory network(s), frontline workers, sales personnel, and customer equipment
  - Entertainment federation, consisting of entertainment venue (gaming hub), players home, real-life deployments in the field
  - …
- Need flexible interconnection at runtime that carries all service-critical functions across
  - Slicing, bandwidth allocations, service routes, …

***All this needs alignment with compliance, sovereignty, & privacy concerns***

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# The Elephant in the Room

# Artificial Intelligence (AI)

**6G is all about AI-native, is it not?**
**-> AI for 6G**

**...but is it about supporting AI services natively?**

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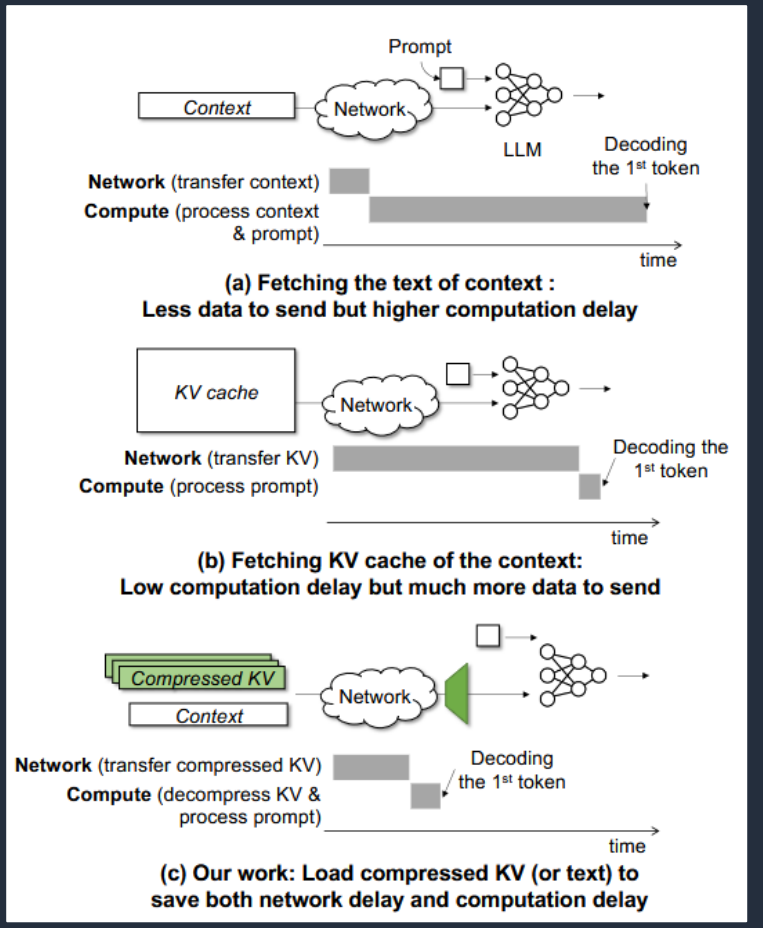
# The Rise of the New Killer Application

**A Deja-Vu**

- **The 90s saw a significant rise of video content delivery over the still young Internet with negative user experience in E2E delivery**
- **Content Delivery Networks (CDNs) were designed, implemented, and deployed at scale to bring video content to end users**

***Modern OTTs like Amazon, Netflix, YouTube and many others would not be possible without the existence of CDNs***

- **AI is the next killer application, like video in the 90s, but at MUCH larger scale**
  - **ChatGPT, launched just three years ago in 2022, and other LLM-based GPT services are following suit, with ChatGPT alone experiencing about 4.5 billion visits in March 2025**
- **AI inferencing can be accelerated through use of KV caches (SIGCOMM2024 [1]), enabling local inferencing instead of relying on the central LLM data centre**
- **Distributing KV caches is like streaming a video**




[1] https://dl.acm.org/doi/pdf/10.1145/3651890.3672274

**6G and the Future Internet needs *Inferencing Delivery Networks* (IDN) to make AI a working reality in future networks**

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# Challenges in Supporting AI Natively

- **Scale**: AI is more than ultra-large GPTs, it is highly local, private, and distributed
  -> Scale exceeds that of centralised content production and distribution of CDNs

- **Universal access**: Access to AI is a key capability of 6G (not just its use in building the system)
  -> Must ensure that EVERYBODY has equal access and performance to it
  -> Do not leave it to good traffic engineering of local networks!

- **Deep 6G integration**: Not just at the DN level but at UPF level
  -> Solve the service and breakout challenges and you are mainly there!

- **Contextuality & Locality**: AI is deeply contextual as it is alive with new data & is deeply local in usage, not just in delivery but also relevance of data
  -> Context (including but not limited to locality) plays a vital role in delivering but also refreshing AI

- **Freshness**: There is no global knowledge for AI but it lives from local data to be adjusted and refreshed
  -> Native AI support needs to include refreshment of globally distributed knowledge

- **Privacy**: AI is deeply private in MANY parts, e.g., private industry
  -> Native AI must support security through data perimeters, encryption, etc

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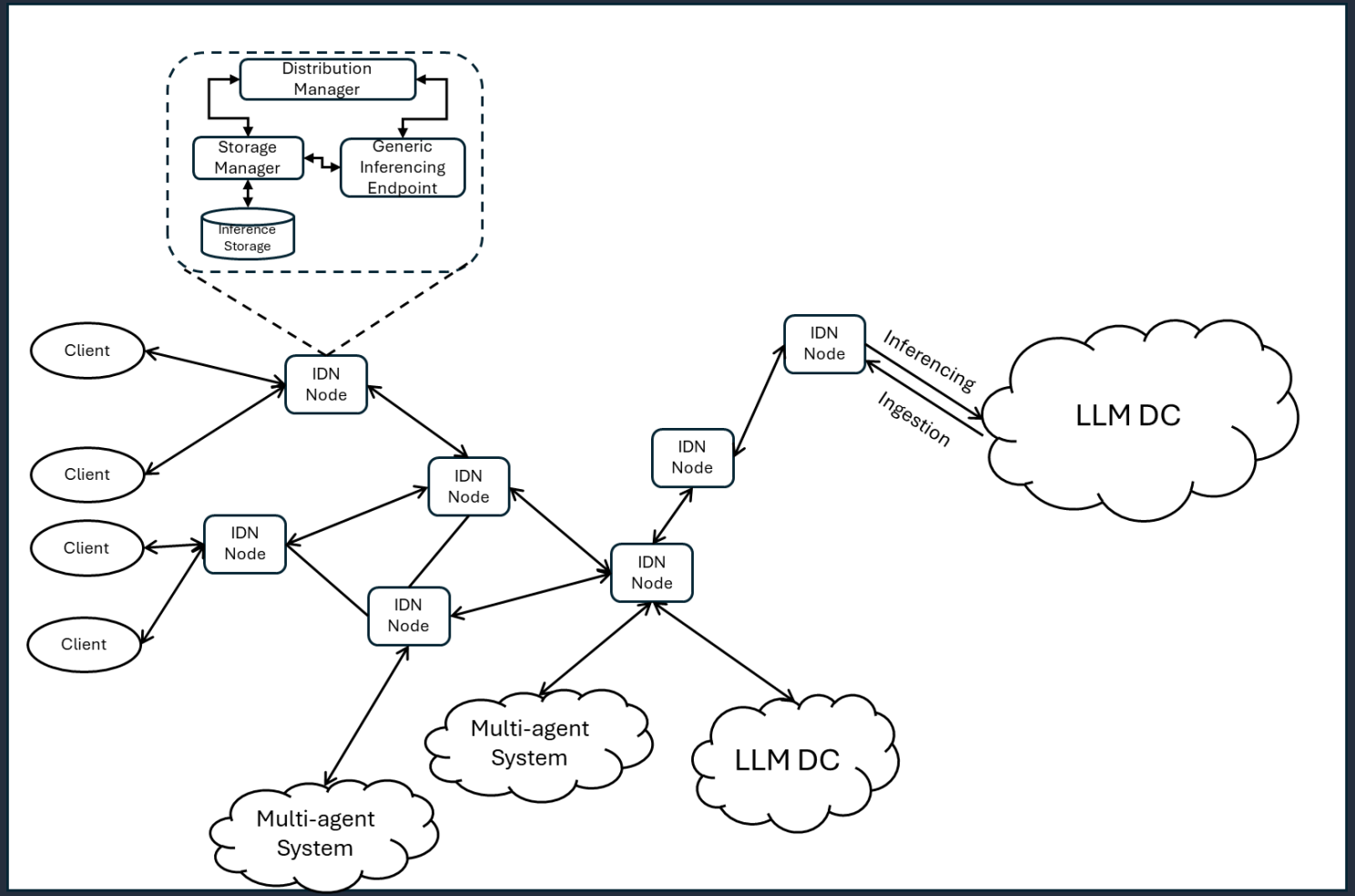
# A Strawman for an *Inference Delivery Network*

- Structured like a CDN
  - Distributed
  - Decentralised
  - Regional
- Push/pull of global knowledge
  - Driven by localised context
- Localised operations
  - Processing (not just retrieval)
  - Contextualisation
  - Freshness



# Conclusions

**5G has brought us a long way, enabling highly customised private networks**

**6G has to fill remaining gaps to make P5G an even more pervasive reality**

**BUT we must tackle the elephant in the room – AI – to not fall into the same trap as with video in the 90s**

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# THANKS FOR YOUR TIME

Get in Touch !

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