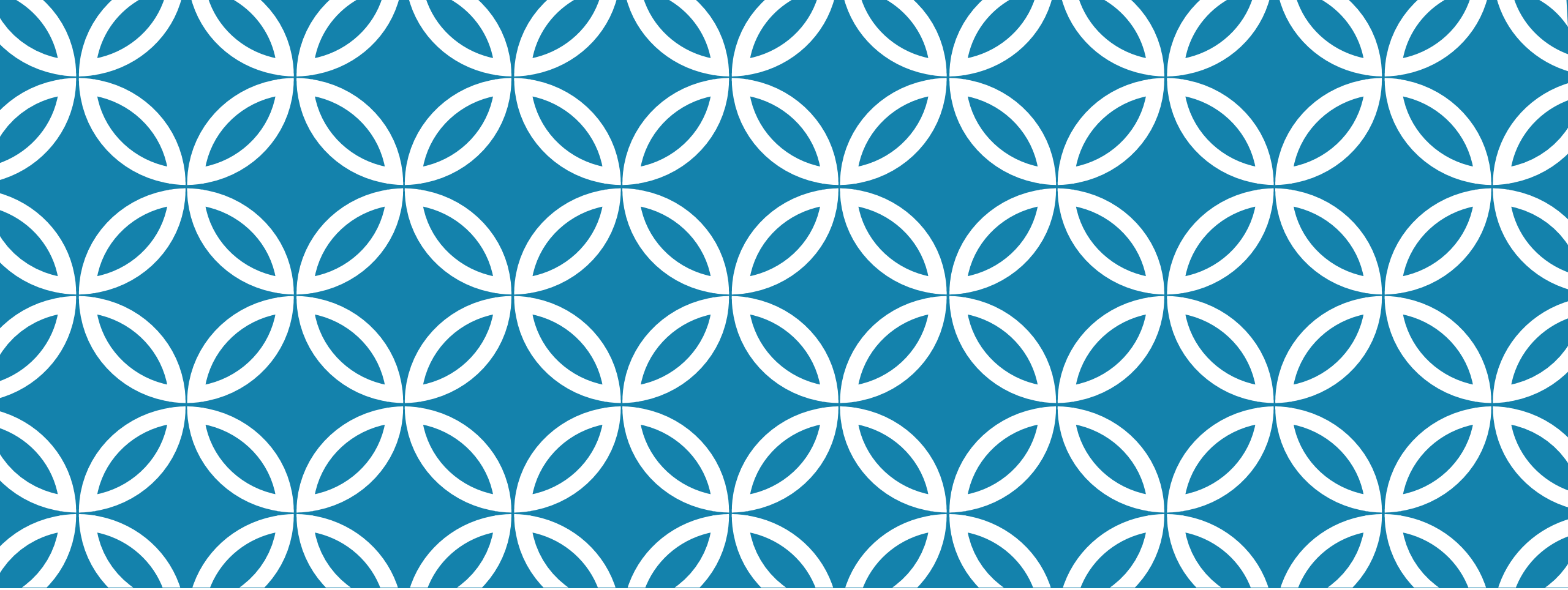

6G RESEARCH DIRECTIONS

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MOTIVATION

- 5G deployment ongoing
- Next phases (e.g., 3GPP Rel. 18) covering enhancements towards
  - More efficiency, (access) heterogeneity, network slicing, data analytics based automation, readiness to SDN/NFV, cloud, and open source, service awareness, …
- Ultimate 5G systems' dream to enable some 'futuristic' applications may come very late
- … thus 6G research worldwide started
- Note
- Following slides are based on IEEE Future Networks Webinar by Prof. Henning Schulzrinne on Do We Still Need Wi-Fi in the Era of 5G (and 6G)? On Feb. 4, 2021 https://futurenetworks.ieee.org/education/webinars#5GWi-Fi

OUTLINE

- Converging into a single stack
- Carrier networks in 6G
- Non-carrier networks
- Spectrum agility
- What kind of network?
- Need for new authentication models
- 6G takeaways

CONVERGING INTO A SINGLE STACK

- 2G real distinguishing (and really surprising) factor was text messaging (SMS)
- 4G was offering multimedia services, gave birth to YouTube, WhatsApp, and smartphone era started
- 5G to reduce cost per Giga bits/bytes
- 6G will be to fully bring to life vision of 5G
- 5G and 6G no longer purely based on carrier mobile network infrastructure but resemble a unified network

CARRIER NETWORKS IN 6G

- It is no longer one subscriber, one phone, one provider model
- Structure of how we operate networks should be based on an economic model
- Currently many 3rd parties, software companies (Google, Apple, etc.), backhaul, spectrum Database, etc. make up the carriers
- Whole stack is no longer operated by a single operator, network operations outsourced in many countries

NON-CARRIER NETWORKS

- Fixed Wireless Access (FWA) home networks
- Venue networks at airports, stadiums
- Factory networks (carriers may wish to operate, but system integrators seem more likely) such as 3GPP NPN (Non Public Networks)
- C-V2X cellular vehicular to everything replacing earlier 802.11p based DSRC (Dedicated Short Range Communication) for C-ITS (Cooperative Intelligent Transport Systems)
- For carriers, opportunity to get back their enterprise business and for vendors new opportunities

CITIZENS BROADBAND RADIO SYSTEMS

- For CBRS currently in USA spectrum at 3550 – 3700 MHz (CBRS band) is assigned
- Enables private networking by enterprises, any technology can be used
- Currently only LTE
- CBRS range: 2-6 miles on 200-250 ft tower, customer antenna at 20-30 ft - or:

  3 – 10 kms on 10-13 m tower, customer antenna at 1-1.5 m

SPECTRUM AGILITY

- *Wi-Fi and 5-6 G have similar PHY: OFDM, OFDMA, QAM, MIMO*
- **Spectrum**
- **5G:** 700 MHz, 3.5 GHz, 26 GHz, 60 GHz
- Wi-Fi: 2.4 GHz, 5 GHz, 6 GHz
- Actually **using separate bands for these very similar technologies** no longer makes sense
- Business models are different, user equipment, modem/data cost very different
- We have opportunity for the same device to operate easily in multiple bands, so don't no longer need national spectrum availability, local availability is useful
- Devices will be more spectrum agile, able to use whatever spectrum available

WHAT KIND OF NETWORK?

- Divergence based on business model
- Low monthly bandwidth cost residential, High bandwidth indoors → Wi-Fi
- High bandwidth outdoors → 5G
- Outdoor regional or urban Public transit, metering, traffic signaling → LoraWan
- Connected vehicles → C-V2X
- Outdoors, shipping, rural areas → (LEO) Satellites, Starlink
- Single technology/business models unlikely to dominate
- Network value is much higher than PHY

NEED FOR NEW AUTHENTICATION MODELS

- Current model based on human using the machine
- 802.1X certificate model
- What we need for IoT is hardware based admission model:
- "Should I admit the Smart Teapot blinking red and blue?"
- "Here's a list of device manifests – add them to the network"
- "Admit the device I just touched"
- "Admit the blinking device I'm pointing the camera at"
- "Admit the device playing a melody"

LOOKING INTO 6G

- Just doing PHY based requirements, take 5G PHY and multiply or divide by 10 is waste of time
- Instead look at architecture overall complexity of overall system
- Stacks always focus on data while complexity is in control plane
- Two evolutionary paths:
  - like 4G & 5G, just more highest mobility
  - 6G as PHY technology dominating plus some new authentication and carrier related technologies
- Protocols matter, but programmability matters more
- Most IoT programmers and factory automation specialists will not be computer scientists (and won't have a telecom background)
- Socket API, Java network API, network input as scripting language variable are examples of good programmability

LOOKING INTO 6G

- Separate link layer from network architecture
- Why can't 5G (or 6G) NR operate on a home router, without a carrier?
- Assume flexible spectrum access (geo database)
- Every interface must be testable and self-testing
- *Interface neutrality* = every control needs to be accessible to network consumer, not just operator (bounded by slice or authorization)
- Clean interfaces particularly at layer 2 and 3
- No configuration files, ever
- No hard-coded addresses (e.g., gateways), ever

LOOKING INTO 6G

- 6G needs an architecture re-think, not (only) better PHY
- Cleaner separation between media/complexity-dependent layers, common data transport and control planes
- Design scalable, unified IP-based control plane for everything from peer-to-peer mode to managed national cellular network
- Cleanly separate access from backbone
  - since likely continue to be both locally (enterprise) and third-party managed
  - Allow us to leverage fiber availability without doing complicated backhaul mechanism
- Opportunity to bridge the Wi-Fi - cellular chasm
  - It should not matter to the end user which PHY is being used, and change it by tuning to a different spectrum band

Q&A

- Which of the issues/ideas presented in previous slides can we derive new work in 6GIP (esp. slides 10-13)?