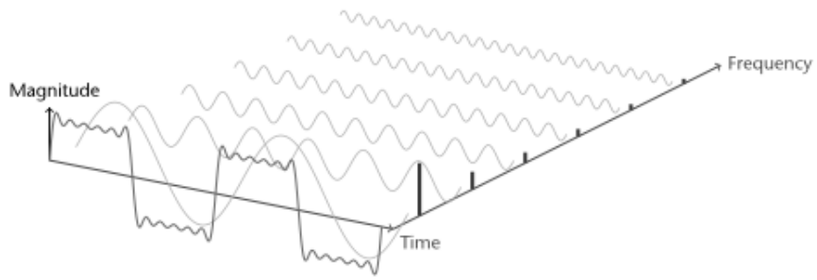
EEU4C21/CSP55031/EEP55C26:
Open Reconfigurable Networks

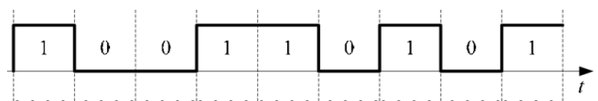
Module Outline

What you have covered so far…

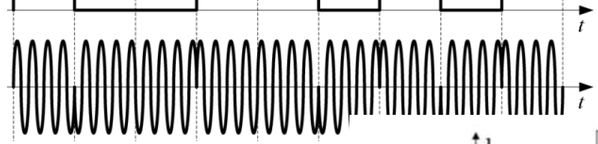
- Signals: time domain / frequency domain, Fourier series, MATrix LABoratory…

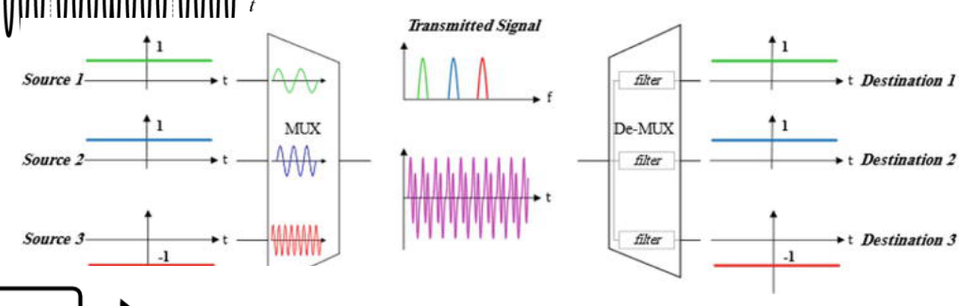
```
% Always comment your code
a = [1 1 1 1];

% Loopy way of doing it
b = [];
for ind = 1:1:4,
b = [b 1]; end;

% Built-in function to do the same
c = ones(1,4);
```



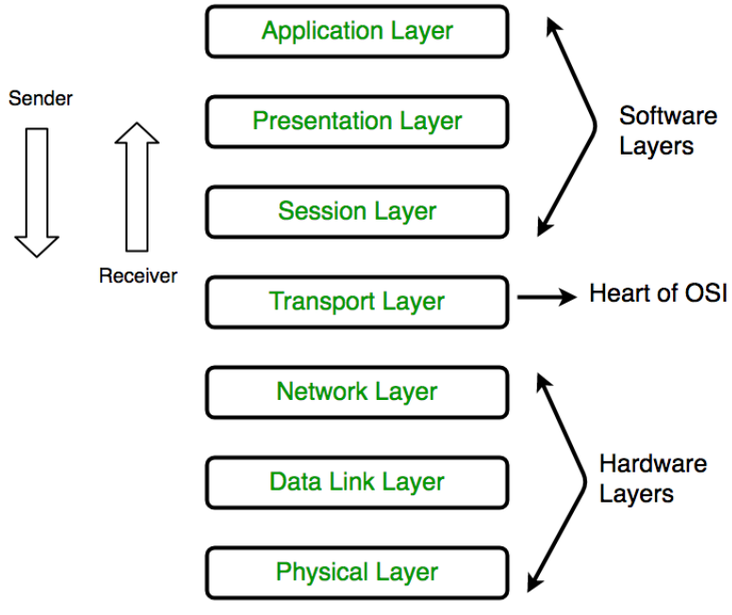


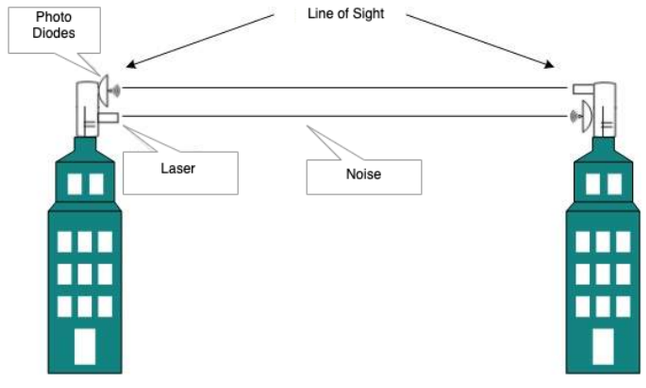
- Communication: Modulation, Multiplexing, Transmission, Medium access schemes, Routing, Channel effects…



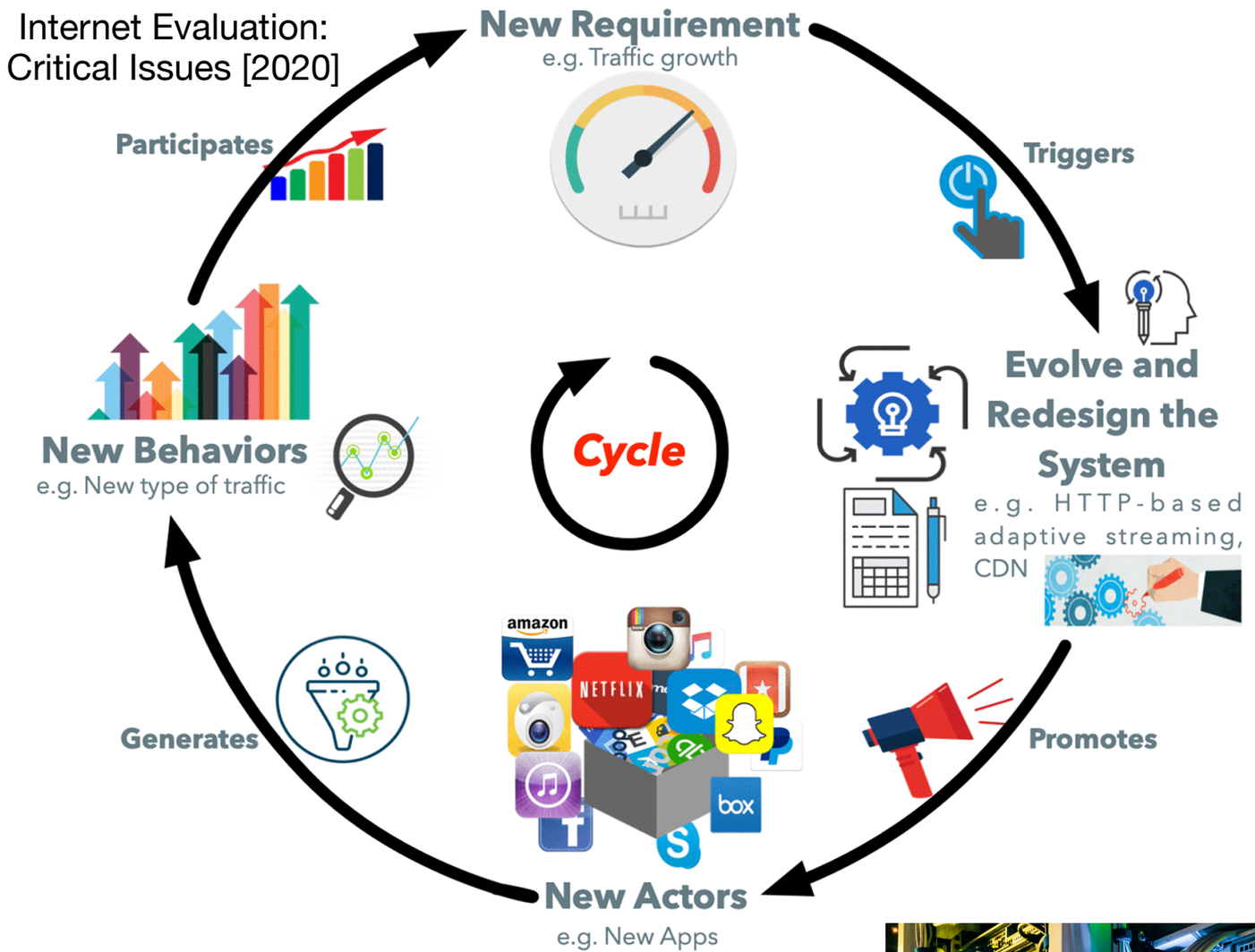


- Network stack & Protocols TCP, Application layer, Network security…

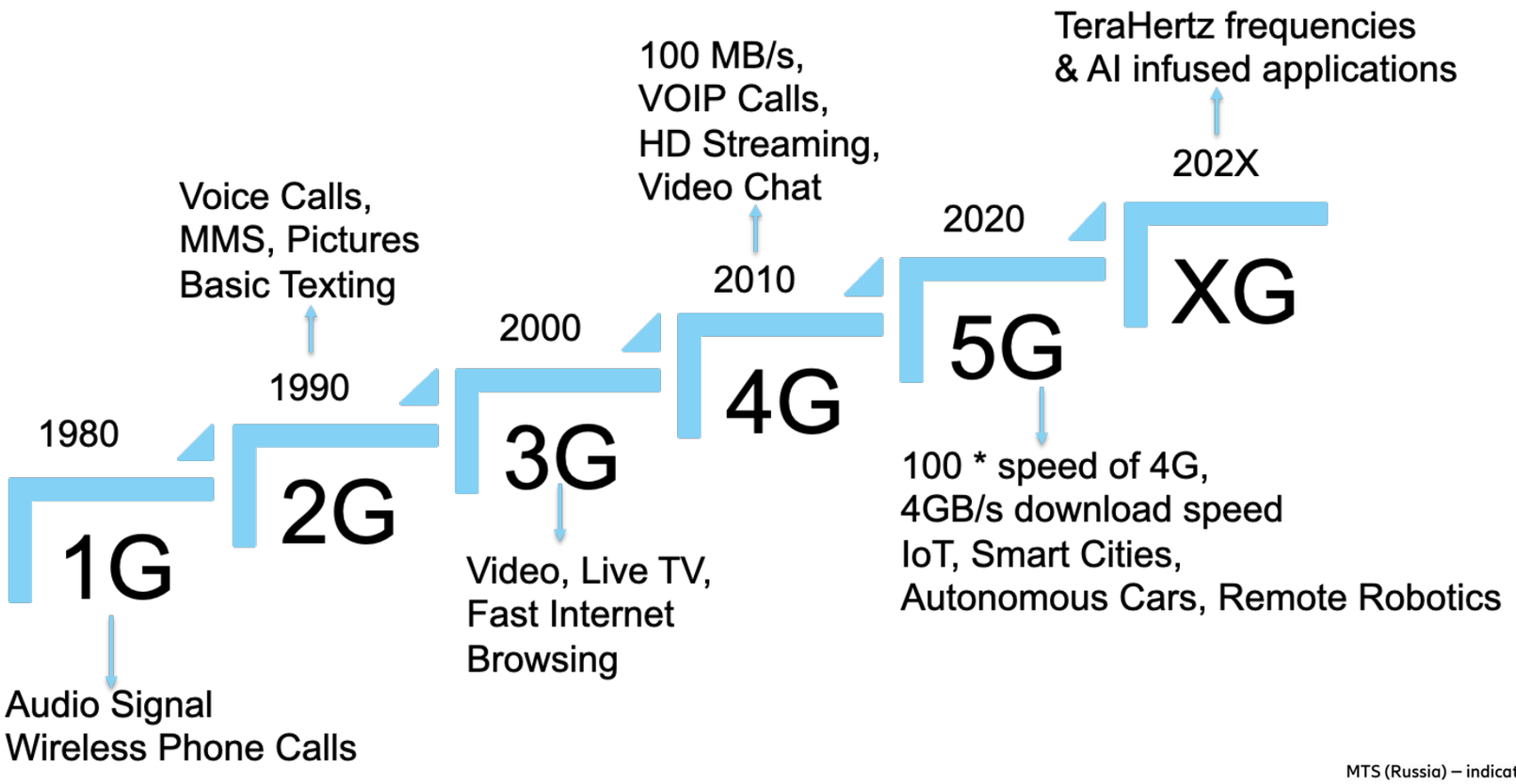


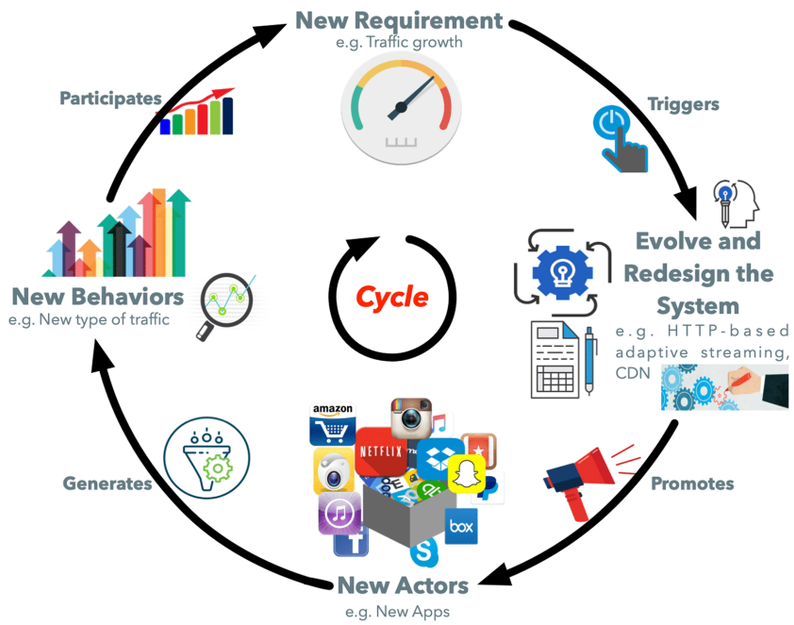


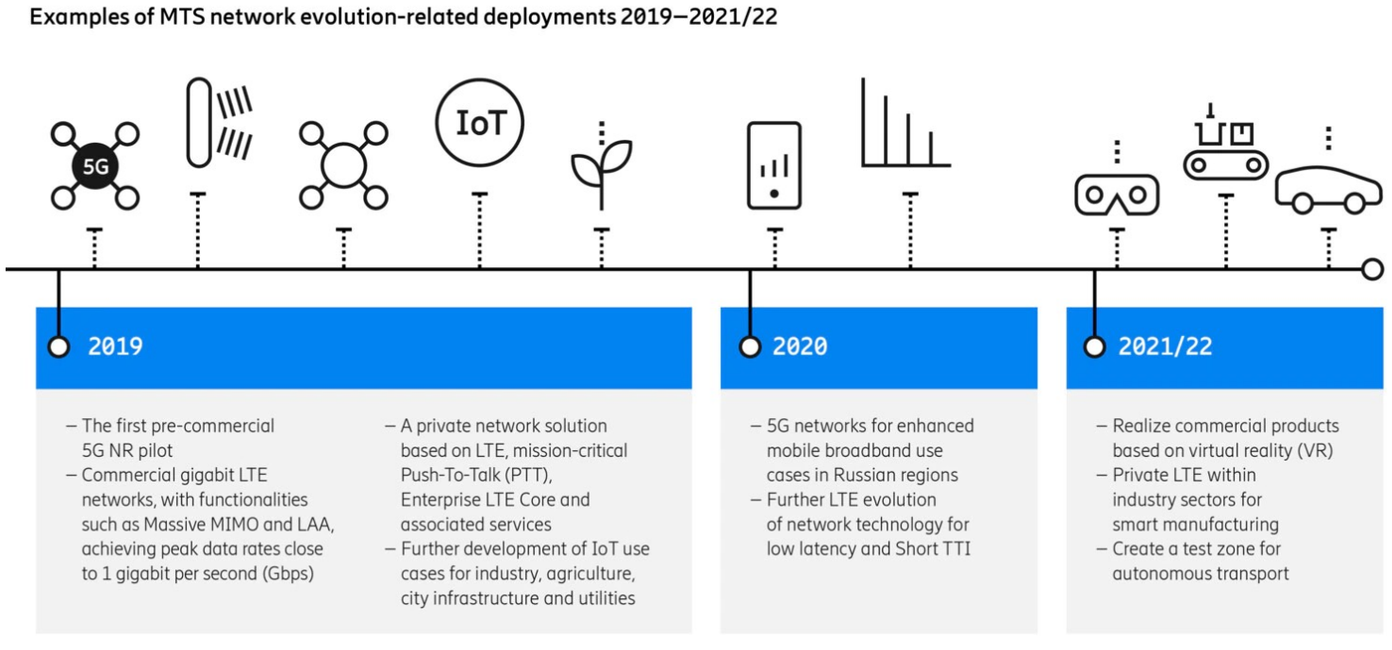
Network evolution

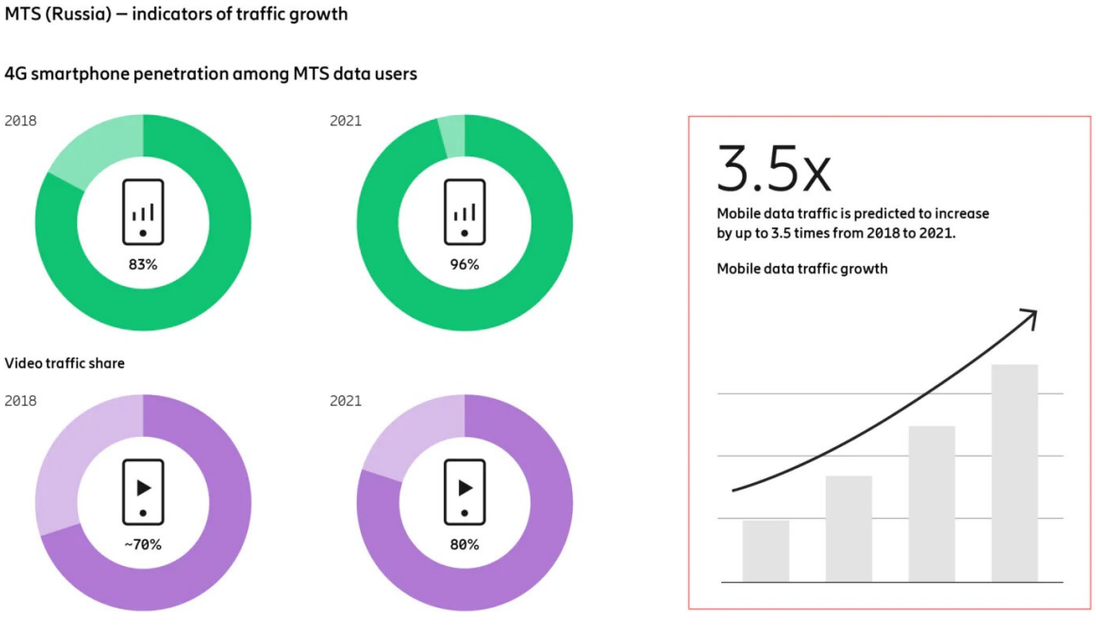


Network evolution



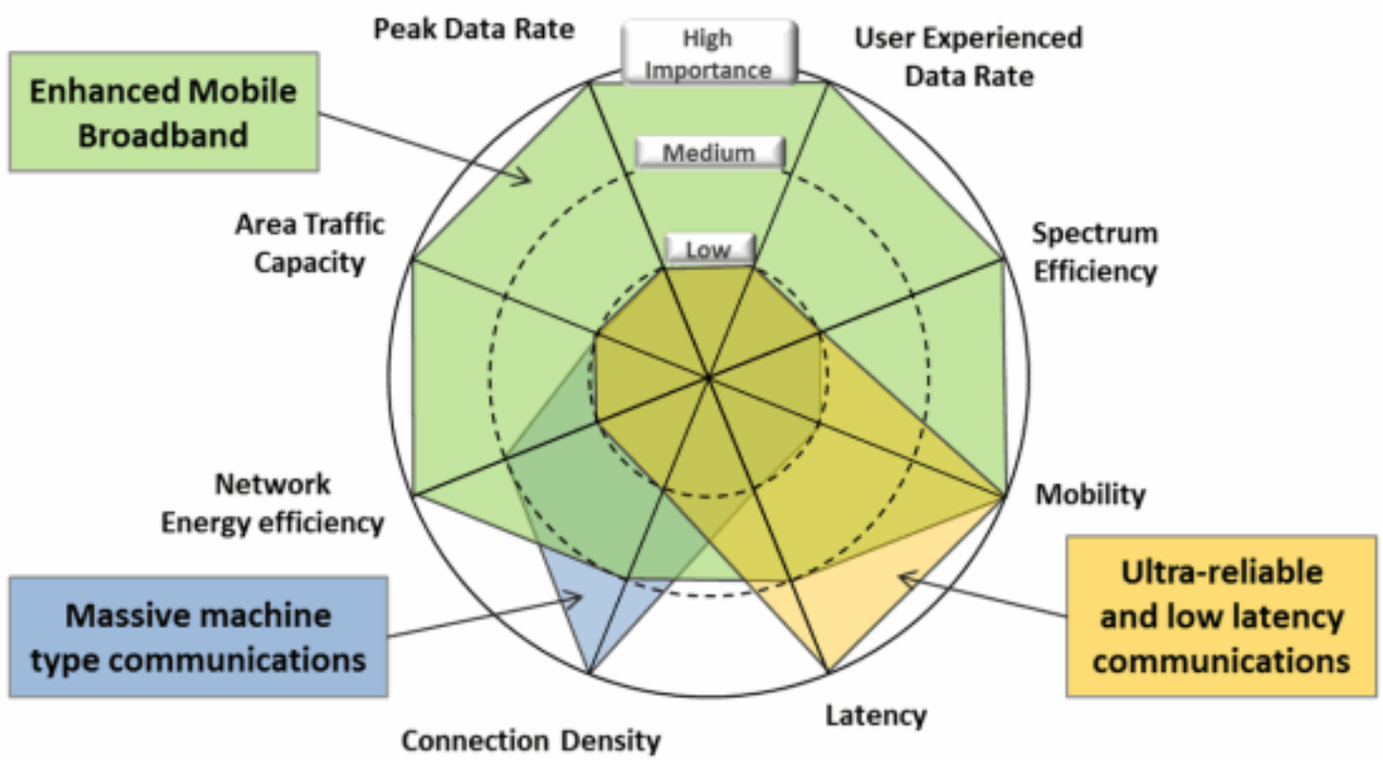






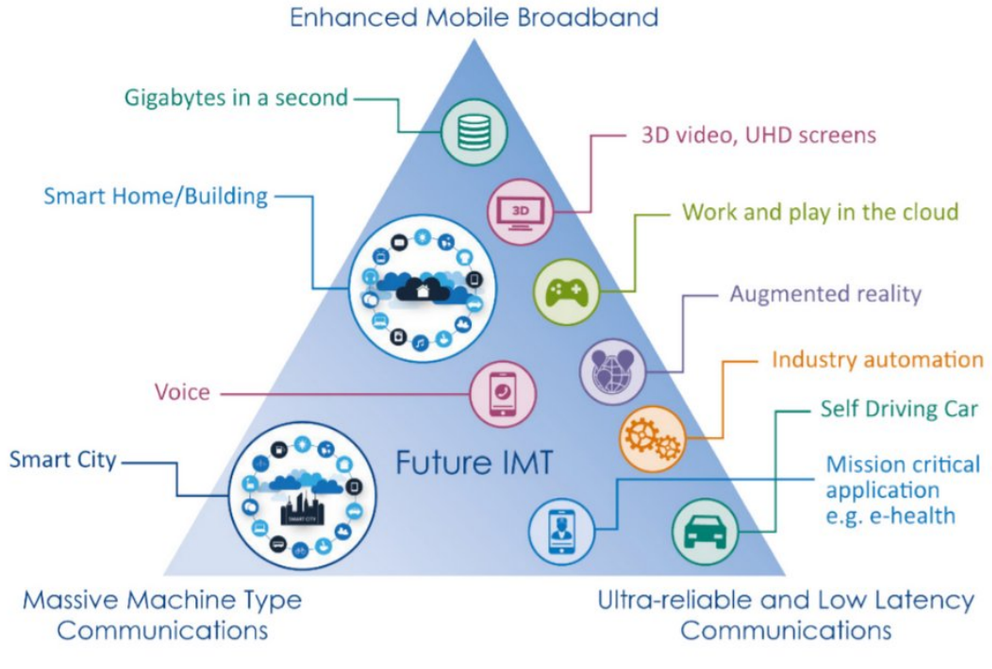
Source: Ericsson Network Strategies towards 5G

What does it mean for network entities?

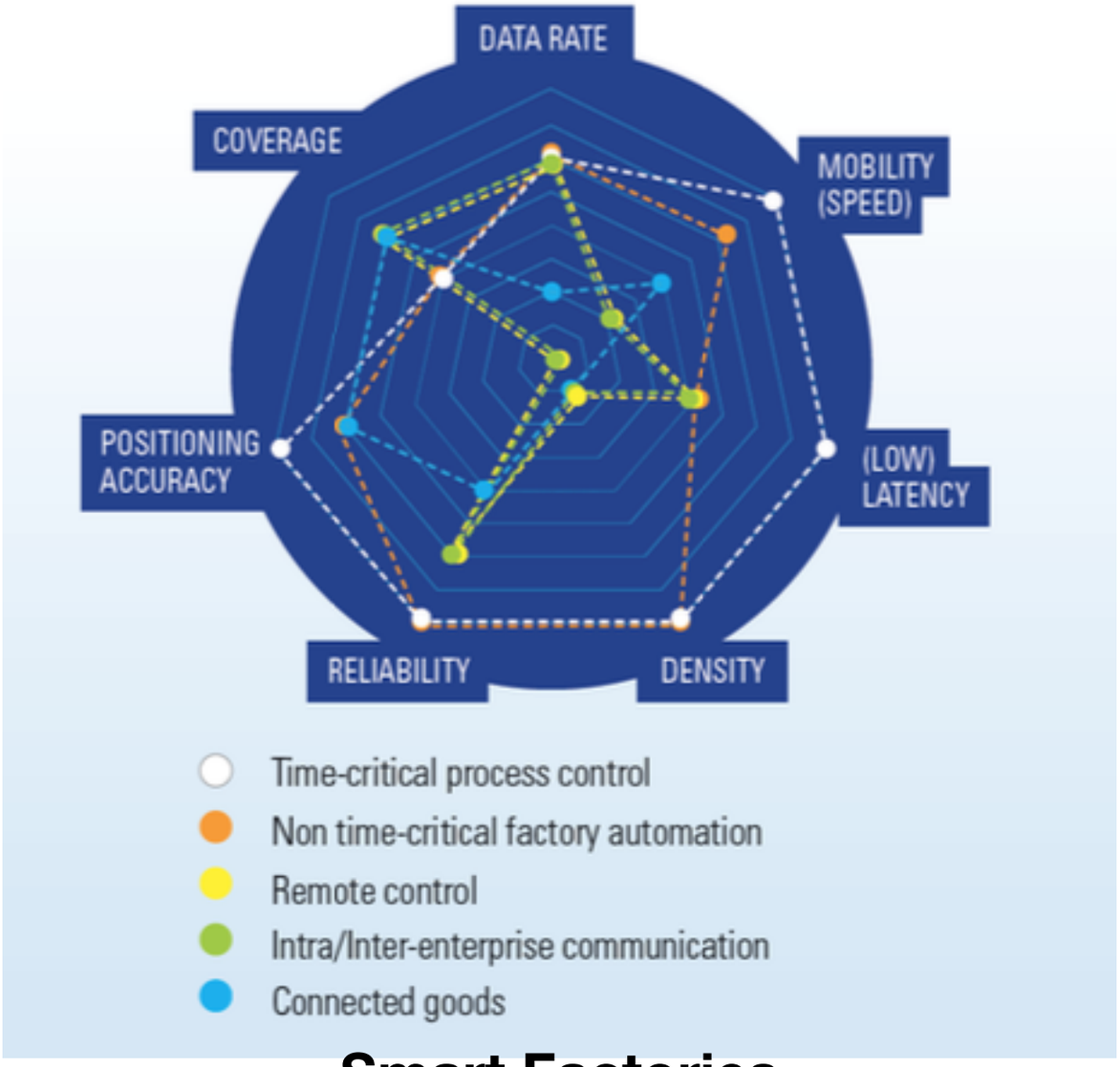


Source: ITU 5G Key Parameters

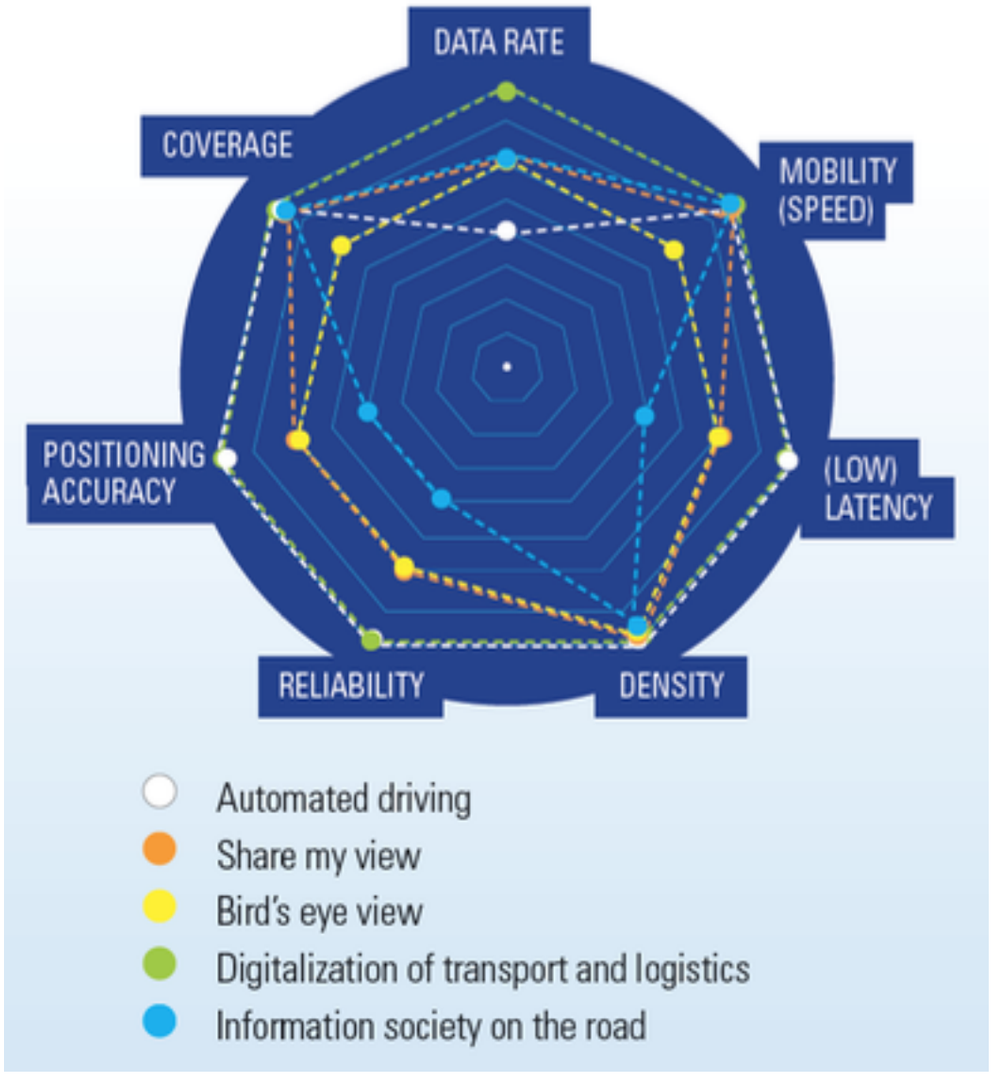
5G usage scenarios



What does it mean for network entities?



Smart Factories



Connected Vehicles

Source: 4C4

- Networks have to be smarter - tailor services corresponding to application

- Flexible/Programmable/Reconfigurable network architectures are key enablers

Network softwareization

Def: Overall approach for *designing*, *implementing*, *deploying*, *managing* and *maintaining* network equipment and/or network components by software programming (ITU Y.3100)

Pave way towards network components as a service (i.e., **X as a Service**)

- Everything from user's application to (virtual) network functions and (software-defined) network controllers as a service

Increase **Network flexibility**

- New components can be *instantiated* on-demand
- Adapt to dynamic deployments and information requirements

Increases network management complexity in favour of network programmability

What is this module about?

This module is about `Open Reconfigurable Networks'

- As we have seen, communication networks are a key ingredient in many modern applications

- Flexible, scalable communication infrastructure to cater to rapid advancements in many domains - from telecom to biomedical to physics, space and others

- Ability to `reconfigure' the networks through software enables smarter network protocols, applications and infrastructure

- This module delves into the programmable and reconfigurable aspects of fixed and wireless networks through

    - Software-defined Radio for wireless communications

    - Software-defined Networks in fixed networks

Module organisation

- Three contact hours per week
    - Lecture slot: Monday 12:00 to 13:00, M21
    - Lecture/Lab slot: Thursday 11:00 to 13:00, AAP CADLAB
- Lecturers
    - Prof. Marco Ruffini on SDN and fixed networks
    - Prof. Shreejith Shanker on SDR and wireless networks
- Grading
    - 100% CA (no end of year exams), split 50% between SDN and SDR parts
        - 80% Labs, 20% on 2x In-Class Tests

Let’s start with a basic communication flow

Information Source

↓

Conversion to EM Signal

↓

Transmission Medium

↓

Conversion from EM Signal

↓

Information Sink

Sensors, Machines, Computers, A/D …

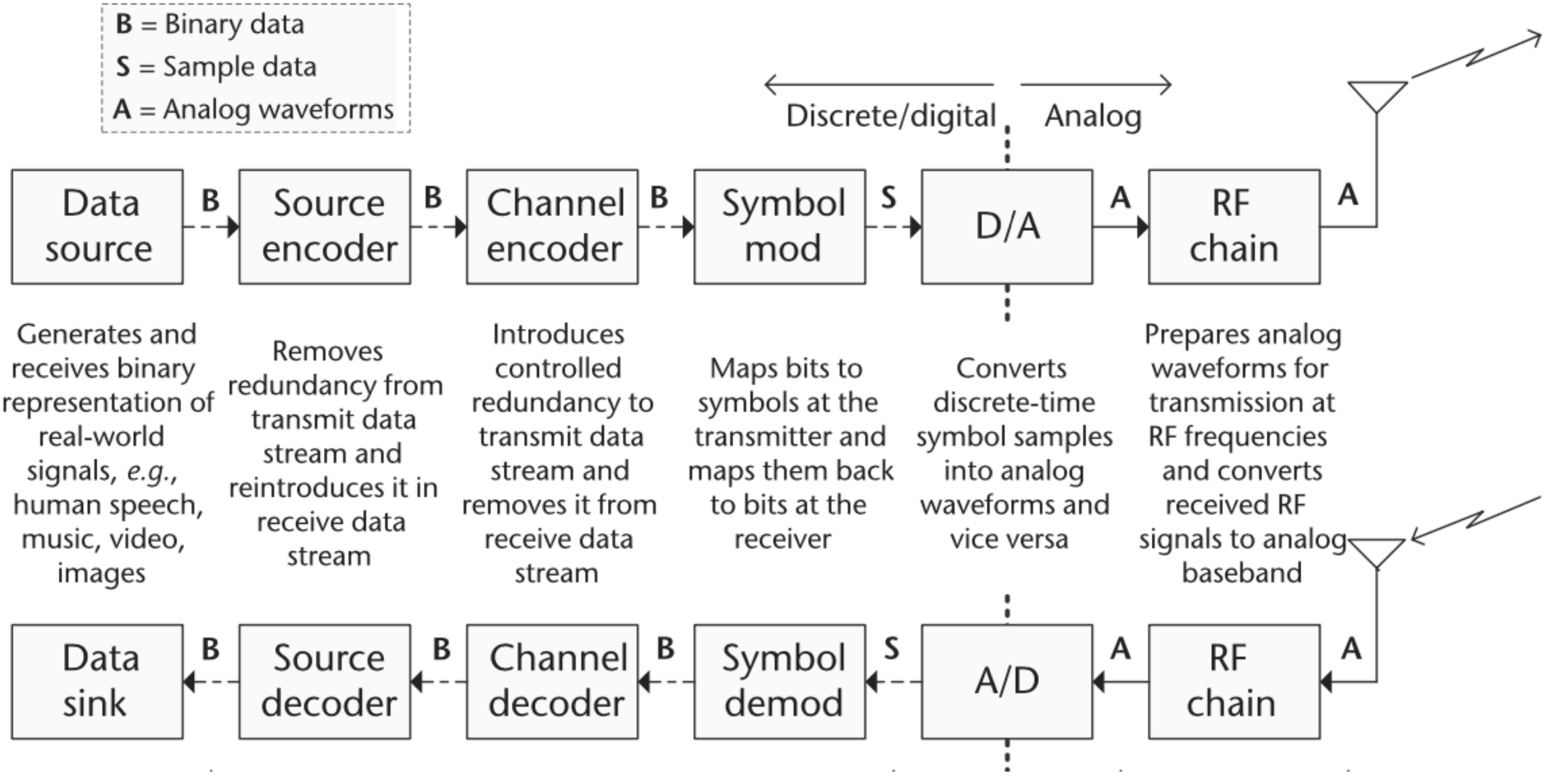
Sampling, Discretisation Encoding, Modulation, Upconverstion …

Copper wire, Twisted shielded pairs, Optical Fibre, Wireless…

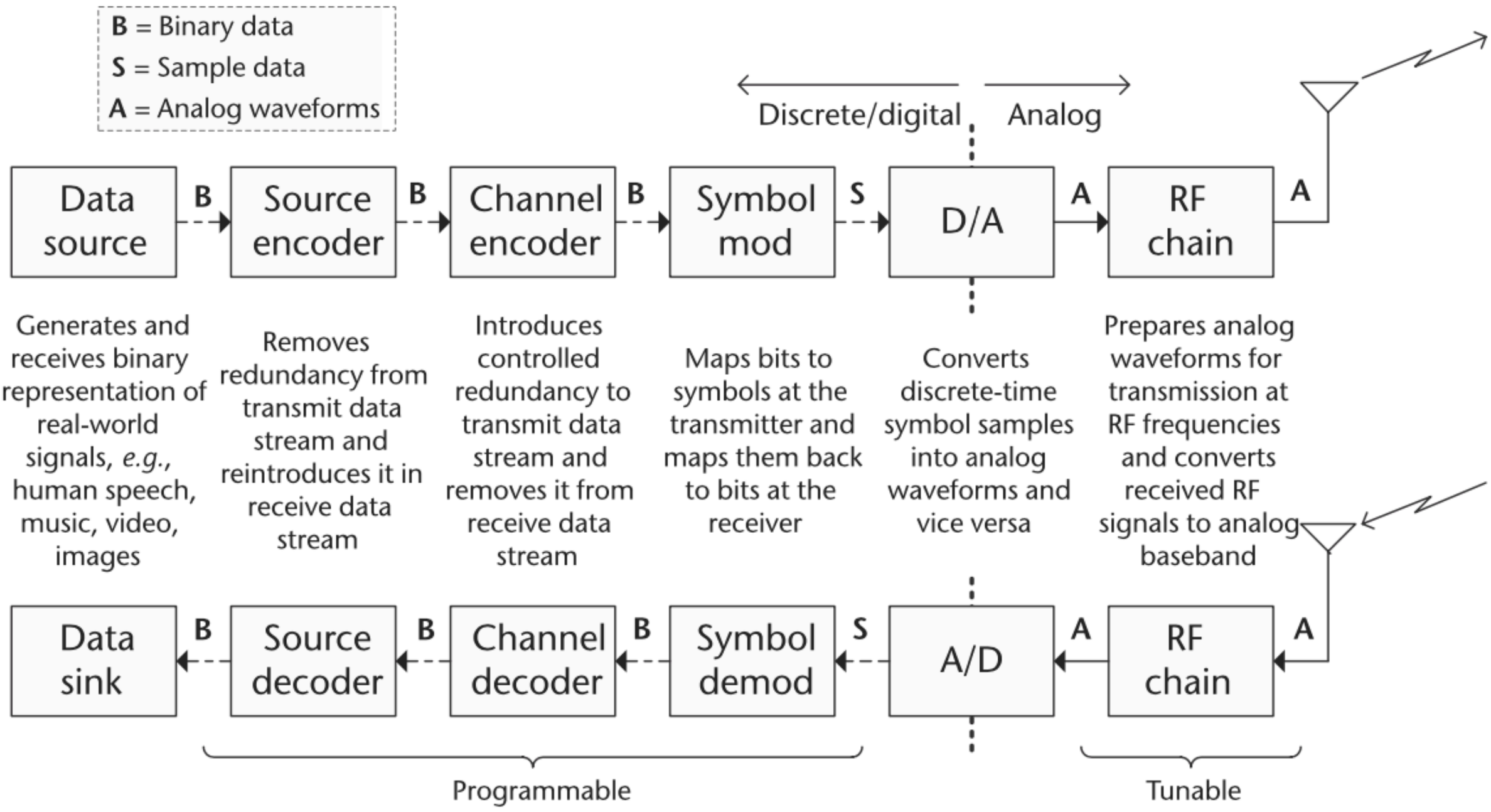
Downconversion, Demodulation, Estimation, Decoding, D/A …

Actuators, control systems, processing logic …

Modern Wireless Radio



`Programmable' Radio



Processors, FPGAs, GPUs **Tunable RF front-end**

`Programmable' Radio

- Radio systems were always 'baseband' processing with RF front-ends
    - Advancements in semiconductor technology (Moore's law, transistor designs, new materials)
        - More capable processing for baseband —> advanced and flexible communication systems
        - RF Transceivers are more *versatile* and *powerful* —> single chips that can handle wide range of frequencies and bandwidths
- Flexible RF + Programmable Baseband + Dynamic control via software
    - Radio functions entirely implemented in digital logic and software
        - Rise of 'Software-Defined Radio' or SDR

What do we cover in SDR?

- Introduction to SDR
    - Platform overview, programmability, and revision of some communication systems fundamentals
- Implement digital communication systems using SDR platform
    - Use an ADALM Pluto device to receive and transmit information using different schemes
    - Explore spectrum sensing and shared spectrum access
- Explore some practical issues around wireless transmission e.g., timing errors and perform some analysis

What we do not cover

- Channel models
- Network protocols
- Analog and/or baseband communication systems
- Antenna design
- Communication systems theory (except when absolutely required)

Tools used in the SDR part

- MATLAB and Simulink
    - Based discrete time systems, digital signal processing and communication tools
    - Some probabilistic models, when required
- Analysis
    - Performed using MATLAB - while other tools exist, we won’t be exploring them in this module
- SDR Platform
    - Analog Devices ADALM-PLUTO will be used for this module, although most functions can be ported to other platforms with minimal effort

Module administration: SDR

- Hands on module
    - Labs are the key component - learn through building SDR systems
    - Lectures in the week cover key theoretical concepts
- Labs start from week 2
    - First week lab session is used for lecture
    - Subsequent weeks will have 1 lecture slot (1-hour) and 1 lab slot (2-hour)
    - All labs have some submission - short report in most labs.
    - Week 5 lab is a graded lab - requires a demonstration in the lab slot
- **Assessment**: SDR portion (50% of 4C21) is fully CA based
    - 5% each all Labs (weeks 2, 3 and 4 —> 15%), 25% on graded Lab (week 5), 10% for in-class Quiz (week 5 or 6).

SDR: Lab Schedule

Week	Content	Title	Submission
2	Intro to SDR	Lab 0	Short report
3	AM System with SDR	Lab 1	Short report
4	Modern communication system with SDR and Performance Analysis	Lab 2	Short report
5	SDR for IoT	Lab 3 - Graded, requires demo:	Short report
5/6**	Quiz on SDR	Week 5/6 Lecture slot	Online quiz on BB

Blackboard

- Must be registered to take the course
- All notes and lab handouts will be uploaded in advance
    - Prepare prior to lab sessions to make the best use of them
- All lab submissions to be uploaded via Blackboard
- Quiz in week 5/6 also via Blackboard
    - Setup your preferences accordingly to ensure you get announcements on-time.

Lab 0:

- Introduction with MATLAB/Simulink, using the toolboxes, interfacing SDR with MATLAB
    - Ensure your device works correctly with MATLAB
        - Explore some analysis and observation tools - spectrum visualisation, time-domain signals, scopes, filters…
- Minor labs lead into the graded lab (Lab 4), so do not miss them.
- Submissions help in case you have issues with the demo in Lab 4 (10% for report, 15% for demo)

Getting help

- **Ask questions** in the lecture and labs
    - Complete the minor labs, use the assistance of the staff in the labs if unclear
- Use the lecture/lab sessions to discuss issues
    - Email in case of doubts and for clarifications
- Don’t wait till the end of week 4!