1. What is the V2X communication?

   V2X is the wireless data exchange between vehicles and between vehicles and available infrastructure. It can be seen as an enabler for safer, greener, more connected and autonomous transport

2. What is the role of ITS/C-ITS?

   Main goal of ITS is to use advanced applications for different modes of transport to better inform traffic participants over various forms of wireless communication related services intended to increase road traffic safety, minimize environmental impact, and improve traffic efficiency

3. List two applications which used I2V for the information dissemination and provide a brief description of these applications

   - Traffic Lights Violation Warning: It is used to warns the driver to stop at the legally prescribed location if the traffic signal indicates a stop and it is predicted the driver will be in violation
   - Intersection and Cross Traffic Assistant: It informs the driver about crossing vehicles with right of way, especially when there is no line of sight between crossing vehicles

4. Outline the challenges faced by the Emergency Electronic Brake Lights (EEBL)

   - Information reliability: EEBL cannot tolerate successive packet losses
   - Communication latency: the network shall provide short end-to-end latency of CAMs
   - A highly accurate positioning system is required in order to avoid false positives as well as false negatives

5. List the steps performed within the Vehicle Merging assistant

   - Merging vehicle sends a merging request per Single-Hop Broadcast
   - All vehicles in the vicinity may reply with the readiness to help
   - The merging vehicle chooses relevant vehicles upstream of the merging area and broadcasts its merging trajectory
   - Relevant vehicles on left lane will cooperatively create a merging gap after a trajectory planning and inform the merging vehicle

6. Why is V2X-Standardization important?

   - Enable interoperability of implementations from different vendors
   - Ensure interconnection among V2X systems and components

7. List the different layers of the ITS reference architecture

   - Application
   - Facilities
   - Networking and Transport
   - Access Technologies
   - Management
   - Security

8. What is the role of the management and security entity?

   - Management entity is responsible for the configuration of an ITS station as well as the cross layer information exchange among different layers and tasks
   - Security entity is responsible for security and privacy services

9. List the class of applications based on collision type running at the applications layer

   - Longitudinal
   - Lateral

10. Explain the functionality of the facilities layer

    The facilities layer provides generic functionalities that can be shared by several applications and their assigned use cases. It enables the capability to store, aggregate, and maintain data from different type and source

11. What is the purpose of the Basic Transport Protocol (BTP)?

    BTP enables a end-to-end, connection-less and unreliable transport service similar to UDP

12. Explain the difference between the control and service channel

    - Control channel is allocated to exchange high priority safety messages and other control information
    - Service channels are reserved for safety or non-safety usage

13. List the main entities of the facilities layer

    - Information support
    - Communication support
    - Application support

14. What is the task of the station positioning?

    The station positioning provides absolute 3D position information (latitude, longitude, altitude) of the station. It permanently processes information received from several captors (GPS, vehicle sensors, etc.) and fuse them to get the mobile station position information

15. What is the task of the service management entity?

    Service management entity manages the station life cycle services through downloading of new customer services, up-grading or removing of existing services

16. What is the content of the Local Dynamic Map (LDM)?

    LDM is a digital map comprising lane-specific information including curves, pedestrian walking, bicycle paths and road furniture such as traffic signs and traffic lights. It contains also all dynamic objects that are directly sensed or which presence is indicated by other road users

17. What is the requirement of the time management?

    Time management requires an accurate global time clock used for the timestamping of generated messages

18. What is the purpose of Cooperative Awareness Messages (CAMs)?

    CAMs are messages exchanged between stations to create and maintain an awareness of each other

19. Outline the task of CA basic service

    The CA basic service is a facilities layer entity that operates the CAM protocol. It provides two services: sending and receiving of CAMs

20. Why does a received CAM shall not be forwarded to other stations?

    The CAM is transmitted only in a single hop to the receiving station located in the direct communication range of the originating station. Forwarding CAM could create a so-called broadcast storm which will fully overload the wireless channel

21. On which channel are CAMs disseminated?

    As the CAM contains highly dynamic status information of the vehicle station, it is disseminated on the control channel

22. Outline the CAM generation rules and provide a motivation behind

    A new CAM is generated if

    - the current heading of the vehicle differs at least 4 degree from the heading in the last CAM, or

    - the current position of the vehicle differs at least 4 m from the position in the last CAM, or

    - the current speed of the vehicle differs at least 0.5 m/s from the speed in the last CAM

    Through this mechanism the load of the wireless channel could be substantially reduced so that a high level of awareness between vehicles can be achieved. Unnecessary status updates from many senders, e.g., for standing vehicles, could lead to channel congestion

23. Give the maximum and minimum of CAM generation rate

    - Maximum time interval between CAM generations is 1000 ms. It corresponds to the CAM generation rate of 1 Hz

    - Minimum time interval between CAM generations is 100 ms. It corresponds to the CAM generation rate of 10 Hz

24. What is the reason of CAM timestamping?

    CAM timestamping is used to derive the freshness of the information received

25. Outline the structure of a CAM

    A CAM is composed of a common message header and multiple containers: a basis container, a high frequent container, a low frequent container and a special container

26. Which information is mandatory in CAM?

    Information about vehicle type, current geographic position as well all fast-changing parameters such as heading and speed of vehicle is mandatory in CAM

27. Briefly explain the function of each container inside the CAM

    - Basic container provides basic information of the originating station such as vehicle type, geographic position

    - Vehicle HF container contains all fast-changing (dynamic) status information of the vehicle station such as heading or speed

    - Vehicle LF container contains static or slow-changing vehicle data like the status of the exterior lights

    - Special container provides information about the specific role of the vehicle in road traffic e.g, public transport

28. What is the reason behind considering a container concept when building a CAM?

    The container concept ensures a flexible message format that can be adapted to the needs of the sending and receiving vehicle while minimizing the load on the wireless channel

29. List two use cases based on CAM

    - Intersection Collision Warning
    - Emergency Vehicle Warning

30. Consider a car driving at a constant speed on a straight road. Derive the message generation rate of CAMs when driving at 100 km/h and 180 km/h according to the message generation rules

    As the car drives at a constant speed on a straight road, only the traveled distance will be updated

    - 100 km/h = 27.7 m/s, 180 km/h = 50 m/s
    - Generation rate for 100 km/h = $\frac{27.7 \text{ m/s}}{4 \text{ m}}$ = 6.94 Hz $\implies$ 6 Hz
    - Generation rate for 180 km/h = $\frac{50 \text{ m/s}}{4 \text{ m}}$ = 12.5 Hz $\implies$ 10 Hz (Since the maximum CAM generation rate is 10 Hz)

31. What is the purpose of Decentralized Environmental Notification Message (DENM)?

    DENM are used to alert road users of a detected event

32. How does the destination area is represented in a DENM?

    Destination area is represented by the combination of one or several geometric shapes and distance information

    - Circular
    - Rectangular
    - Ellipsoid shape

33. Why does a received DENM shall be forwarded to other stations?

    A DENM is forwarded by intermediate stations in order to disseminate DENM to stations which are not located in the direct communication range of the originating station

34. List the types of DENM

    - New
    - Update
    - Cancelation
    - Negation

35. Outline the difference between a cancellation DENM and a negation DENM

   - Cancellation DENM: Only the originating station which has generated the new DENM could transmit this type to terminate an event

   - Negation DENM: Every station could transmit this type to inform the termination of an event for which the new DENM has been generated by a originating station

36. Draw the structure of a DENM

   A DENM is composed of a common message header and multiple containers: a management container, a situation container, a location container and á la carte container

37. Why does the location container is mandatory when the situation container is present in a DENM?

   Both the location of the event as well as the destination area shall be known when an event (situation) is detected as the location container includes at least:

   - Event location describes the position where the event is detected

   - Destination area sets the geographic area where the messages shall be sent

38. What is the purpose of SPAT message?

   SPAT message is used to inform drivers about the current status and change of the traffic signal ahead as well as when the next signal stage change

39. List two I2V/V2I applications using SPAT messages

   - Green light optimal speed advisory

   - Signal violation warning

40. What is the purpose of MAP message?

   MAP message provides digital topological map, which defines the topology of an infrastructure area including the lane topology and the paths for pedestrian crossings and the allowed maneuvers within an intersection area or a road segment