Korte Afstand Radio interface specification

Interface Requirements Specification

Vehicle system - Road system

Document History

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27 September 2001	1.22	Stop point id (actual and last stop point passed) limited to domain value 999.999.999 in Appendix D, KAR Stop message
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Abbreviations

ACK	Acknowledged, in interfaces used for signalling correct reception of message
ASCII	American Standard Code for Information Interchange
BBA	Brabantsche Buurtspoorwegen en Autodiensten
CVN	Contactgroep Verkeersregeltechnici Nederland (Contact group of traffic engineers)
DRIS	Architecture for systems improving the quality of public transport in terms of Doorstroming, Regelmaatsbeheersing, Informatievoorziening and Stiptheid ((Speed, regularity, Providing of Information and Punctuality, examples are process control systems, s, traffic light priority systems
ISO	International Standard Organisation
KAR	Korte Afstand Radio (short distance radio)
NAK	Not Acknowledged, in interfacing used for signalling incorrect reception of message
OSI	Open Systems Interconnection
RDR	Rijksdienst voor Radiocommunicatie (Dutch radio communication agency)
RPP	Request priority passage
SID	System identification
SOH	Start Of Header
TBD	To be defined
UML	Unified Modelling Language
UTC	Universal Time, Coordinated
VRI	Verkeersregelinstallatie (Traffic control installation).

Description of Used Terms

Character Stuffing	Adding of an extra control character to interface data before sending and removing it after reception to distinguish between control character and data, if control character appears in data.
Emergency services	The services provided by the police, fire brigade and ambulance.
Roadside System	Intermediate system between Vehicle System and Traffic Light system
Vehicle System	Vehicle computer and peripherals

1 Scope

1.1 Identification

This document describes the KAR protocol which is used for the communication between vehicles that may get priority (such as public transport vehicles, emergency services etc) and roadside systems (such as a VRI). This document is written for suppliers of vehicle systems and roadside systems. With this document, they should be able to program the software for the standard communication protocol.

1.2 System overview

This document describes the protocol by using the seven layers of 'The Reference Model' of Open Systems Interconnection (OSI) as developed by the International Standards Organisation (ISO).

The message protocol is defined with state diagrams of the Unified Modelling Language (UML).

1.3 Document overview

This document is organised in the following sections:

- Section 2 contains the referenced documents
- Section 3 contains the interface requirements
- Section 4 contains the interface specification for each layer of the 'The Reference Model' of OSI.

2 Referenced documents

The following documents are referenced in this document:

[CVN] ‘Beschrijving van de software-interface tussen het applicatieprogramma en de procesbesturing voor verkeersregeltoestellen’ , specifiek hoofdstuk “ Selectieve voertuiginformatie”
Version: 3.1, 31 may 2005
Pusblisher: CVN – commission ‘C’

[RADIO-MODEM] User requirements and test results radio modem DRIS Version 2.3 9-106-2003
Author: G. van der Peet, Joost Boor (Transmis b.v)
Publisher: Transmis bv.

[RADIO-MODEM2] Functional specification for a radio modem for use with the KAR Protocol
Version 1.0, 15-08-2003
Author: A. Stickland
Publisher: Wood and Douglas Ltd

2.1 Referenced Document Erratum

Erratum to […]:

3 Interface Requirements

The goal of this document is to specify a standard radio communication protocol that should be used in the Netherlands for DRIS functions by vehicles and road systems. A road system can be a VRI, depot system and a bus stop.

This section describes the functional interface requirements to be met by this interface. Section 4 will describe the interface specification and where applicable will describe the interface based on the requirements given in this section.

3.1 Application area

This interface specification can be used for the following DRIS function:

1. To request priority passage. This request is used on any passage where the vehicle wants to get priority on other traffic.
   In particular this message is used at traffic lights, selective access (at barriers) or for notification for passing a bridge.
2. To send departure information to a bus stop.

The radiomodem and the interface specification may be used for the following DRIS functions on different frequencies:

3. To send vehicle position information to a central vehicle monitoring system.
   This information can be used by a central system to monitor the progress of the vehicles running the timetable. It can also be used to calculate predictions of arrival times at bus stops.

4. To download or upload large quantities of data to a vehicle. This can be timetable and route data (planning) or logging information.

The functions 3 and 4 will not be defined in this document. However, it is possible with limitations, to use the ‘request priority message’ also for functions 4.

3.2 The Reference model

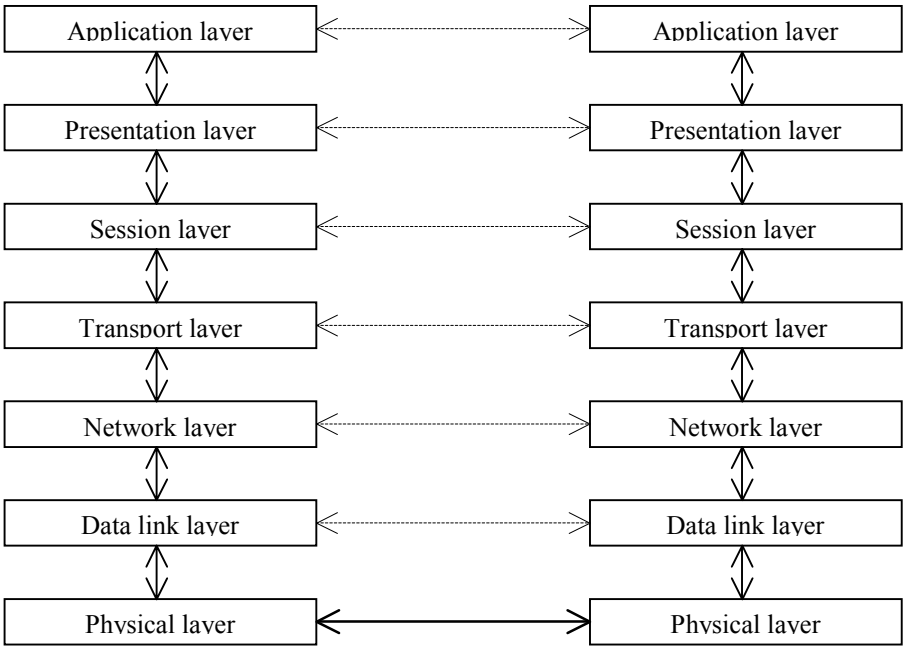


Figure 1 ISO OSI Reference model

Figure 1 contains the Reference model that is used to specify the communication protocol. For each layer a protocol is specified to communicate between the same layers on different stations. In reality, the data will never be directly send to the other station but the data is passed to the layer immediately below it. Only the lowest layer, the physical layer, will communicate with the other station. When this reference model is used it is possible to change the protocol of one ore more layers. This may be necessary in the future when the medium used to communicate is changing. It is then only necessary to change the lower layers (starting at the Physical layer). The layout of the messages as specified in the 'Presentation layer' does not need to be changed.

This will fulfil the requirement that it should be easy to change the medium used to communicate.

3.3 Security

No specific security requirements are defined in the protocol. Security measurements may be defined at different levels:

1. Protection against unauthorised use of the priority request messages.
   For unauthorised people it may be interesting to sent priority request from a vehicle in order to get priority. If somebody wants to do this he or she should have inside information of the users of the system such as the used frequencies, the protocol, addresses, crossing number (sid's), signal group numbers, valid vehicle numbers etc.).
   The road owners do not think it is necessary to realise extra security measures in order to prevent unauthorised use.
2. Protection against a denial of service attack.
   With a strong directed transmitter the radio channel may become useless. It is not possible to prevent this. In this situation the RDR should take measures and find out who uses the frequency unauthorised.

3.4 Priority

If possible messages with a high priority will arrive with less or no delay at the destination. This mechanism should be used for messages from vehicles of emergency services (police, fire-brigade or ambulance) to increase the chance that the message will be send as early as possible.

3.5 Technical requirements

In this document, there will be no explicit technical requirements specified, only functional requirements. This will give suppliers the opportunity to choose the best solution for the implementation of this protocol. The only exception on this rule is the technical requirements of the modem used for the radio communication. These requirements will be described in section 4.7.

In pilot projects for radio communication between vehicles and road systems modems are used for the physical communication. These modems use a RS232 interface to communicate with the computer of the vehicle or road system. The 'data link layer' is implemented in the computer. When the protocol is implemented, this construction should be used.

4 Interface specification

4.1 Application layer

The contents of this layer depend on the supplier implementing this interface specification.

4.2 Presentation layer

In this layer, the messages as interchanged between applications are described. First, the message contents will be given followed by the message protocol on this layer.

In this section only the messages which are public are described. The other message examples as given in section 3.1 are private and will not be defined here.

At this time 2 public messages are defined:
- Request for priority passage.
  This is sent from a vehicle to a roadside system. This can be used when arriving at a traffic light, barrier or a bridge.
- Stop message
  For the communication from a vehicle to a (local) passenger information unit (= piu, processor). This can be used to wipe the information regarding a trip at arrival/departure at a stop point.

Constraints:
Maximum message size (including header, checksums etc) 255 bytes without expansion

4.2.1 Message & protocol specification priority request (Traffic light)

4.2.1.1 HEADER SPECIFICATION

Fieldname	*Size in bytes*	*Range*[1]	*Description*
Message type	1	0..255	0 = Reserved 1 = Request for priority passage 2 = Stoppiu message 3..200 = Reserved for future use 201..255 = Private messages.
Message contents			The size depends on the message type. The message contents are described in the next sections.

[1] When the range contains a negative value the value will be defined in 2's complement otherwise it will be an absolute value.

4.2.1.2 'REQUEST FOR PRIORITY PASSAGE' MESSAGE SPECIFICATION

MessageType 1 'Request for priority passage'.

If a variable exceeds 1 byte, the lowest significant byte is sent first.

CVN Nr	*Fieldname*	*Size (in bytes)*	*Range*[1]	*Description*
-	Message type	1	0..255	The value should be 1 for this message type.
-	Used attributes	3	3 * 8 bits	3*8 bits to indicate which attributes of 1 to 24 are used in the message. If a certain attribute is not used, the subsequent attributes move, in order to minimise the total message length. When a number is specified in this attribute and that number is post-fixed with a letter than all attributes starting with that number should be part of the message. (For example: if attribute 21 is on, all attributes 21a, b, c, d, e, f, g and h will be used). The most right attribute in the bit sequence refers to attribute 1. (000000000000000000000001)
1	Virtual local loop number	1	0..127	Owned by Road Owner Unique number within the VRI-number. (The VRI-number corresponds with the SID-number destination in the Datalink-message, see paragraph 4.6.1).
2	Vehicle type	1	0..99	0 – no information 1 – bus 2 – tram 3 – police 4 – fire brigade 5 – ambulance 6 – CVV 7 – taxi8 – 68 – reserved 69 – Police (not in uniform) 70 – Marechaussee 71 – HOV-bus (High Quality PT) 72 – 98, free to use 99 – URO (Unidentified Riding Object)
3	Line number PT	2	0 - 9999	Line-number (internal line number PT-company)
4	Block number	2	0 - 9999	Vehicle Service number/Block number
5	Company number	1	0 - 255	For unique Identification vehicle id
6	Vehicle id	2	0 - 32767	0 – no information For Public transport the grootwagennummer is used (practically in range 1 to 9999) For emergency services the last 4 digits of the 14 digits C2000 number are used (the so called 'own number')
7	Direction at intersection/ signal group number	1	0 - 255	For the direction selection at the intersection, it is suggested to use the signal group number. If this signal group number is not available a right/left/straight ahead switch may be used: 0 = no information 1-200 = signal group number

[1] When the range contains a negative value the value will be defined in 2's complement otherwise it will be an absolute value.

CVN Nr	*Fieldname*	*Size (in bytes)*	*Range*[1]	*Description*
				201 = right 202 = left 203 = straight ahead 204-255 = reserved When only a right/left/straight ahead switch is used, the origin point from where the request is sent should be part of the message (one of the attributes 1, 20 or 21). This origin point is necessary in order to define the signal group for which priority is requested.
8	Vehicle status	1	0 - 99	0 = no information 1 = driving 2 = stopping (at bus stop) 3 = departure from stop (start door close) 4 = stand still (stop, not at bus stop) 5 – 99 = reserved
9	Priorityclass	1	0 - 99	0 = no information 1 = no priority (f.e. only request) 2 = conditional 3 = absolute 4 = alarm light 5 – 99 = reserved
10	Punctualityclass	1	0 - 99	0 = not used, no priority none (absent) 1 = late (1) 2 = on time (2) 3 = early (3) 4 = off schedule (4) 5 – 99 = reserved can be derived from punctuality
11	Punctuality [s]	2	-3600 - +3600	- - early (<0) - + late (>0)
12	Vehicle / train length [m]	1	0 - 255	Vehicle / train length in meters
13	Actual vehicle speed [m/s]	1	0 - 99	Actual speed when the message is sent [m/s]
14	Distance till passage stop line [m]	2	-99 - 9999	Actual distance till passage stop line [meters].
15	Driving time till passage stop line	1	0 - 255	Expected time until passage stop line (without delay for other traffic, for example wait-row) in seconds for the first Traffic Light Controller on the route. Options: 1. *For the activation and pre-announcement point this value is equal to the value in the planning.* *2. If the manual priority request (ready to start)button is used AND the bus is driving AND didn't pass the stop point, the value is: value at initial planned point (input data) – time passed since passage of initial planned point.* *3. When the ready to start button (manual priority request OR Start Door Close trigger) is used AND the bus has passed the stop point or is still at the stop point (in stop window), the value is calculated: actual distance till stop line/actual speed. If this calculated value is greater than the initial value (input data), the initial value is used* *4. If no value in the planning data is available, the expected time until passage stop line Is*

CVN Nr	*Fieldname*	*Size (in bytes)*	*Range*[1]	*Description*
				calculated: *Actual distance till passage stop line [meters] / Actual speed [m/s]. If the actual speed is less than 5 m/s, the actual speed must be set to 5 m/s*
16	Journey number	2	0 - 9999	Journey number
17	Type of Journey or Fortify seq number	1	0 - 99	0 = no information 1 t/m 9 = Sequence number versterkingsrit. Sequence number for extra vehicles on the same public journey 10 = dienstregelingrit (public journey) 11 = dead run 12 = pull in journey (to remise/depot) 13 = pull out journey (from remise/depot) 14 –99 = reserved
18	Route Public Transport	1	0 - 99	0 - no information 1 - route 1 (A-route, away direction) 2 - route 2 (B-route, back direction) 3 ...99, to be used free. For other route-descriptions.
19	Type of command	1	0 - 99	0 - reserved 1 - entering announcement (front side vehicle) 2 - leave announcement (front side vehicle) 3 - pre-announcement (front side vehicle) 4..99 – reserved
20	Activation pointnr	2	0 - 32767	Location-information (in database PT-company) 0 – no information
21a	Location- reference Latitude [degrees]	1	0 - 89	Location conform WGS84, Degrees
21b	Location-reference Latitude [minutes]	1	0 – 59	Location conform WGS84, Minutes
21c	Location-reference Latitude [seconds]	1	0 – 59	Location conform WGS84, Seconds
21d	Location-reference Latitude [hundreds of seconds]	1	0 – 99	Location conform WGS84, Hundreds of seconds [1/100 s]
21e	Location-reference Longitude [degrees]	1	0 – 179	Location conform WGS84, Degrees
21f	Location-reference Longitude [minutes]	1	0 – 59	Location conform WGS84, Minutes
21g	Location-reference Longitude [seconds]	1	0 – 59	Location conform WGS84, Seconds
21h	Location-reference Longitude [hundreds of seconds]	1	0 – 99	Location conform WGS84, Hundreds of seconds [1/100 s]
22a	Year	2	0 - 9999	Actual time of sending message in On board computer
22b	Month	1	1 – 12	
22c	Day	1	1 – 31	
22d	Hours	1	0 – 23	
22e	Minutes	1	0 – 59	
22f	Seconds	1	0 – 59	
23	Reserve	2		To use free
24	Reserve	2		To use free

The absolute times should be given in DCF-77 time (Frankfurt or Braunsweig time).

For the 'request of priority passage' at a traffic light controller the above message is defined, which can be used for all currently defined information needed by the road owners and for all types of vehicles.
The first attribute of the data message is fixed: "used attributes". The other attributes have got a number (of 1 to 24). The numbers 1 to 20 correspond with the numbers of the attributes for selective priority information on the CVN-C-interface, see [CVN]. (The numbers 21a to h and 22 a to f correspond with the numbers 21 - 34 on the CVN-C-interface, the numbers 23 and 24 are reserved to be defined in local situations, on the CVN-C interface these are the numbers 35 and 36)
In "used attributes" a bit on the positions 1 to 24 indicates which of the [CVN] attributes are used. This attribute defines the interpretation of the data message. A and b numbers are always used in combination for a certain attribute.

When this message is used to request priority at a crossing for emergency services than this message should be send to the session layer with high priority.

4.2.1.3 'REQUEST FOR PRIORITY PASSAGE' PROTOCOL SPECIFICATION

Note: this paragraph is a proposal how the 'request for priority' message may be used. The specification regarding the receiving of requests for priority is especially of interest for traffic light controllers that get the priority requests via a decoder (parallel contacts). For other traffic light controllers, who get the priority message serially on the CVN-C interface, the control of the status of the vehicles may be an integrated part of the traffic-control application. The exact usage and timing of the messages should be agreed upon by the owner of the road system and the public transport company for each location.

The protocol will be separated in two parts: the initiator of the message, which will always be a vehicle and the receiver of the message, which will be always a road system.

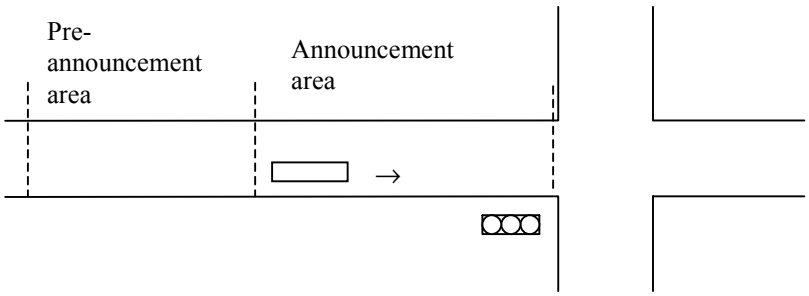


Figure 2 Announcement areas

Figure 2 shows the announcement areas. These areas define the moments 'request for priority' messages should be send. When a vehicle enters the pre-announcement area a 'request for priority' messages with the value 'entering pre-announcement' for attribute 'type of command' may be send. This is an optional message in order to allow the traffic light controller to anticipate on a 'request for priority'. Typically, these pre-announcement messages are only used for old traffic light controllers with only parallel input signals (contacts) and for emergency services to announce the possible passing at the next crossing. For new traffic light controllers with a serial interface the data-message contains the information to anticipate on the passage of a bus (or other vehicle asking priority) at the stop line.
When the vehicle enters the announcement area a 'request for priority' message with the value 'entering announcement' for attribute 'type of command' should be send. The road system will than react on this request.
As soon as the announcement area is exited, which is normally when the stop-line is passed a 'request for priority' message with the value 'leaving announcement' for the attribute 'type of command' should be send'.
On which the road system will continue its normal sequence.

This sequence of messages is described in the following state diagrams given on the next pages.

Messages received at a state on which the message is not defined will be discarded unless otherwise noted.

In figure 3 the state diagram for sending ‘Request for priority passage’ messages is specified. These messages are send by a vehicle. Note, that when a bus enters a pre-announcement area and leaves it without entering the announcement area, for example due to a detour, a message is send to specify it has left the pre-announcement area.

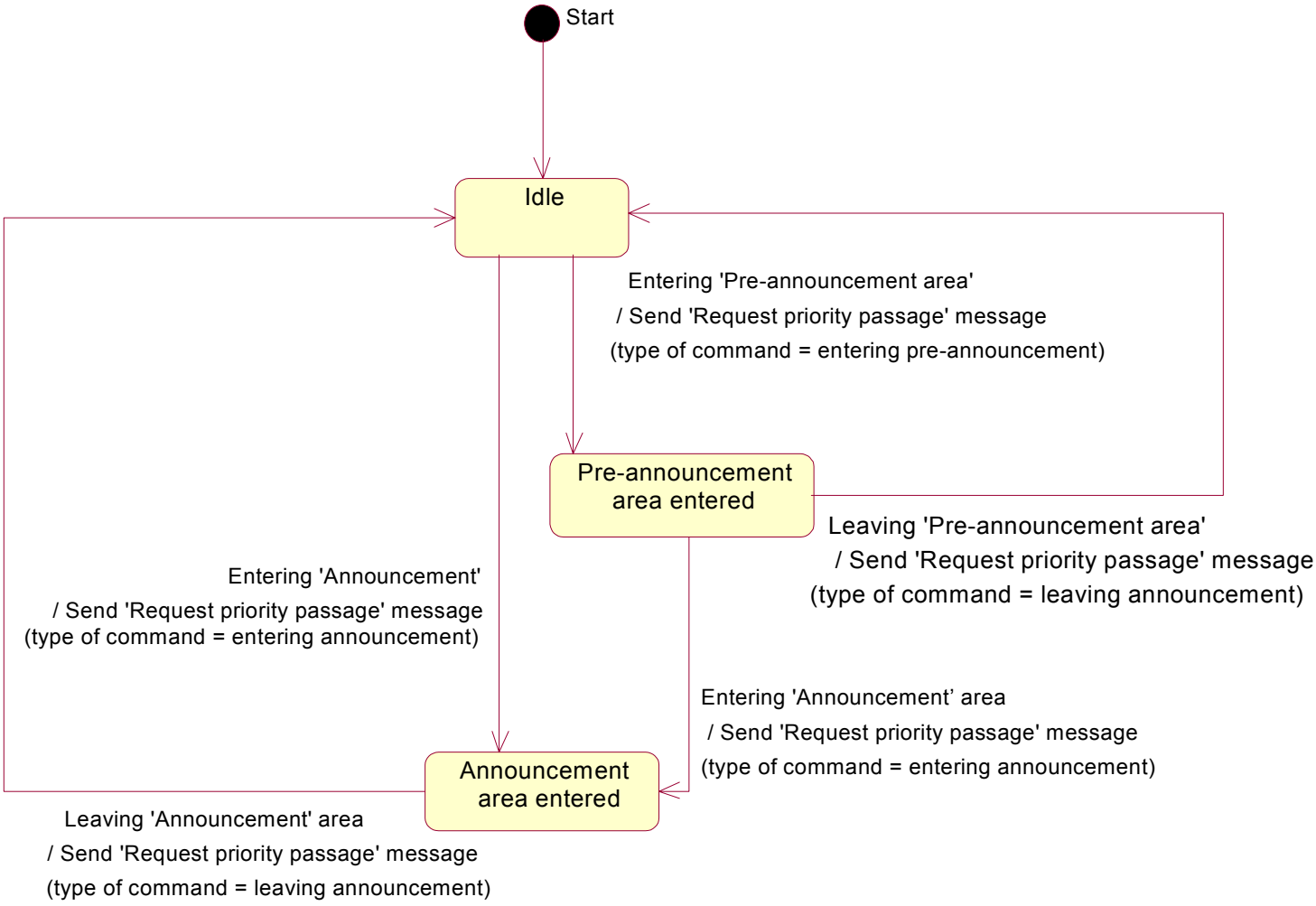


Figure 3 State diagram, sending RPP messages

In figure 4 the state diagram for receiving 'Request priority passage' messages is specified.
The value for the 'Leave Announcement Timeout' (LAT) should be agreed upon by the owner of the road system and public transport company.

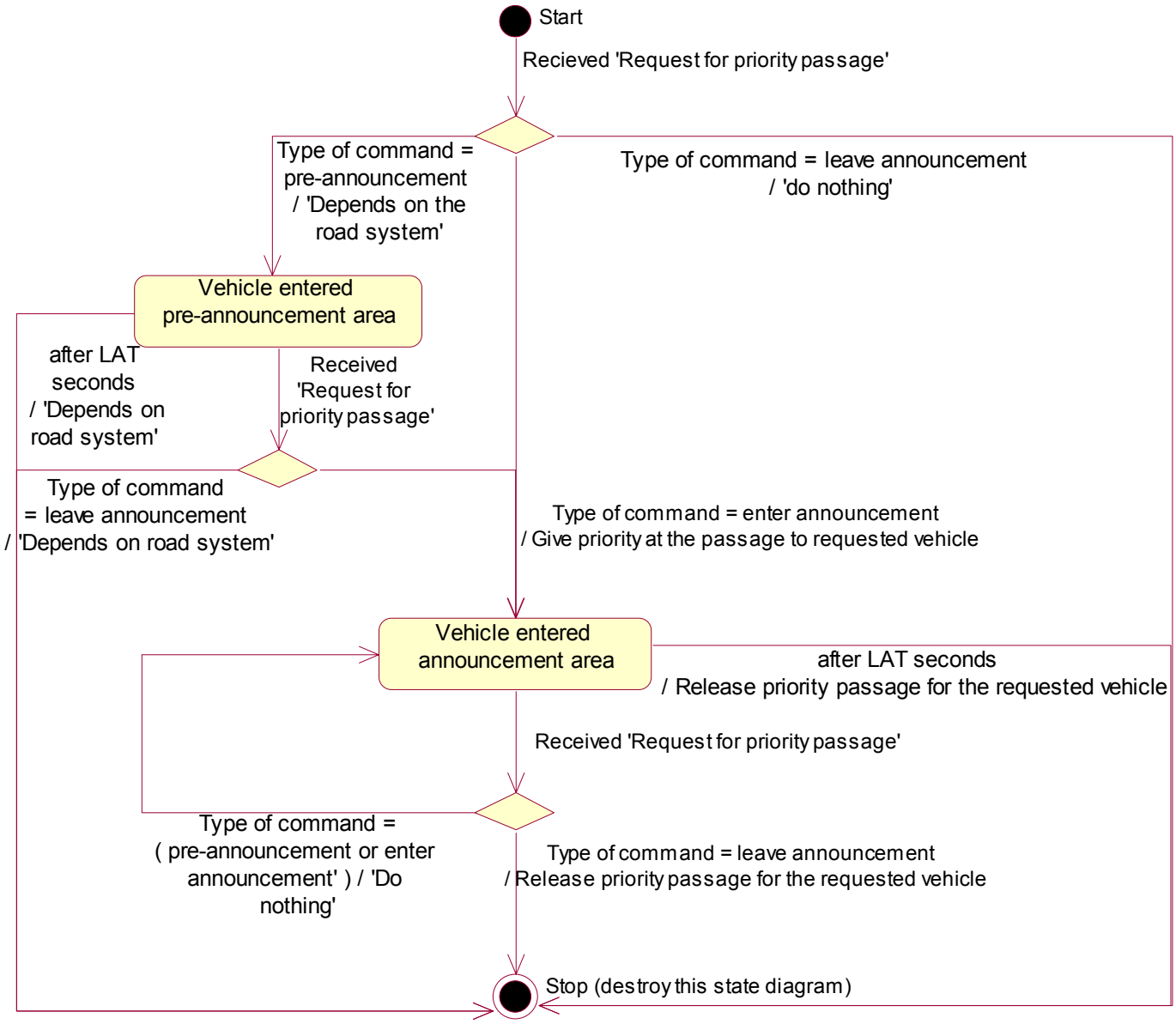


Figure 4 State diagram, receiving RPP messages

Note: the state diagram in figure 4 is specifying the state for one vehicle. When there are more vehicles the road system should create a state machine that handles a state diagram for every vehicle. This state machine will be destroyed if the vehicle has left or should have left (timed out) the announcement area. In figure 5 the state diagram, which will create the state machines for a vehicle is specified.

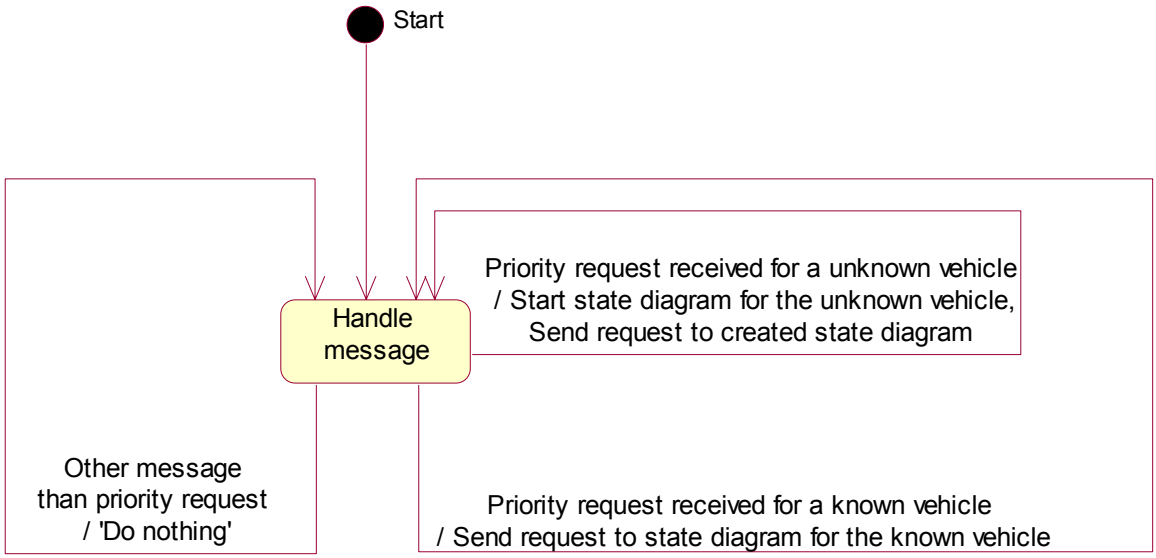


Figure 5 State diagram, creating state receiving state diagrams

4.2.2 Message & protocol specification Stop message (to stop passenger information unit)

4.2.2.1 HEADER SPECIFICATION

Fieldname	*Size in bytes*	*Range*[1]	*Description*
Message type	1	0..255	0 = Reserved 1 = Request for priority passage 2 = Stoppiu message 3..200 = Reserved for future use 201..255 = Private messages.
Message contents			The size depends on the message type. The message contents are described in the next sections.

4.2.2.2 'STOP PASSENGER INFORMATION UNIT MESSAGE' MESSAGE SPECIFICATION (TYPE 2)

Attributes that are also used message type 1 (VRI-message) have the same attribute number (in position counter). This makes the software in a vehicle system that uses both messages simpler.

[1] When the range contains a negative value the value will be defined in 2's complement otherwise it will be an absolute value.

The ‘v’ (compulsory) attributes in the next table is the minimum set needed for a passenger information unit to match the KAR-message to the planning data. (position on the route, journey number). It is recommended to implement the ‘o’ (optional) attributes as parameters in the Intelligent Vehicle System that can be switched on or off.

If a variable exceeds 1 byte, the lowest significant byte is sent first.

Nr	Opt	Attribute	Byte	Value	Description
	V	Type of message	1	2	Code for type message (stoppiu-message)
		Used attributes	3	→	111111101111010010101100 43210987654321098765432 1 (position counter) 2 1
1	-	Reserve	1	0 – 255	To use free
2	-	Reserve	1	0 – 255	To use free
3	V	Line number PT	2	0 – 9999	Line-number (numeric part of public line number)
4	O	Block number	2	0 – 9999	
5	-	Company number	1	0 – 255	For unique Identification vehicle id
6	O	*Vehicle id*	2	0 – 32767	0 - no information
7	-	Reserve	1	0 – 255	To use free
8	V	*Vehicle status*	*1*	*0 – 99*	0 = not used, no priority none (absent) 1 = driving 2 = stopping (at bus stop) 3 = departure from stop (start door close) 4 = stand still (stop, not at bus stop)/ delay 5 – 99 = reserved
9	-	Reserve	1	0 – 255	To use free
10	-	Reserve	1	0 – 255	To use free
11	O	Punctuality [s]	2	- 3600 - + 3599	Actual time -/- timetabled departure time At end stop: Actual time -/- timetabled arrival time - - early (<0) - + late (>0) 3600 = no information
12	-	Vehicle / train length [m]	1	0 – 255	Vehicle / train length in meters
13	O	Stop point id last stop passed	4	0 – 999.999.999	User stop code (in planning system) Used in combination with Vehicle status (attribute 8)
14	O	Distance since last stop point [m]	2	0 – 9999	Used in combination with Vehicle status (attribute 8) and Stop point id last stop passed (att. 13) to define location on the route.
15	O	Stop time at last stop	1	0 – 255	Recorded time of first door close at stop – recorded time first door open at stop (within stop window). Used for monitoring and management information purposes from logged KAR-messages.
16	V	Journey number	2	0 – 9999	Number for identification a vehicle journey within a line number.
17	V	Type of Journey or Fortify seq number	1	0 – 99	0 = no information. 1 t/m 9 = Sequence number versterkingsrit. Sequence number for extra vehicles on the same public journey 10 = dienstregelingrit (public journey) 11 = dead run 12 = pull in journey (to remise/depot) 13 = pull out journey (from remise/depot) 14 –99 = reserved
18	O	Off route indicator	1	0 – 5	May be used to inform passengers in case the bus is detected off route. 0 – no information 1 – On route 2 – Off route 3 - On path
19	V	Type of command	1	0 – 99	0 – no information 1 – arriving at stop point 2 – departure from stop point (leave of stop window)

					3 – pre-announcement 4 – Passage of stop point (without stopping) 5 – Delay (between stops) or stand still at stop point
20	V	Actual Stop point id	4	0 – 999.999.999	User stop code (in planning system) of stop where the bus arrives/departs or passes.
21a	O	RD-X	3	0 – 16777215	Only used when vehicle is detected off route
21b	O	RD-Y	3	0 – 16777215	Only used when vehicle is detected off route
21c	O	RD-Z	2	-99 – 9999	Meters above. NAP, Only used when vehicle is detected off route
22	O	Boarders at last stop	1	0 – 255	
23	O	Alighters at last stop	1	0 – 255	
24	O	Occupancy after last stop	1	0 – 255	

The ‘v’ (compulsory) attributes is the minimum set needed for a passenger information unit to match the KAR-message to the planning data. (position on the route, journey).

4.2.2.3 ‘KAR STOP MESSAGE’ PROTOCOL SPECIFICATION

The KAR Stop message is sent at arrival, departure or passage of a stop point or stop area to which a Passenger Information Unit (with a KAR address is assigned).

Definition
Stop window: the area around a stop point, a number of meters before the stop post and a number of meters after the stop post (stop post is imaginary line where the front site of the first bus stops, mostly the point where the stop post is located). When it is sure the bus has passed the stop window, activations may be triggered. The stop window is defined in the software of the vehicle system and depends on the positioning system used.

The KAR Stop message is sent under the following conditions:
- At arrival on a stop point (door open within stop window), also at the arrival of the first stop (begin stop point of a journey)
  At the arrival of the first stop (begin stop point of a journey) the line and journey number of the departing journey is used.
  Op basis van het KAR-bericht bij aankomst bij de beginhalte kan de halte-processor bepalen in welke volgorde de bussen op een perron aankomen/staan. (dit om een volgordenummer aan te kunnen geven, c.q. de ritten op het display te kunnen sorteren op de volgorde waarop de bussen staan). Het uitzenden van het lijn en ritnummer van de vertrekkende rit bij aankomst is nodig omdat een RIS dat alleen werkt op basis van de publieksdienstregeling (TMI koppelvlak 1), de relatie tussen de aankomende en vertrekkende rit niet kent
- At a departure/passage of the stop point (leave of stop window)
- At a pre-announcement point. This is a point with the “AABS”-trigger, AABS = Automatic Announcement Bus information System
  Bij dynamische busstation is het van belang dat in een pre-announcement bericht het lijn- en ritnummer van de vertrekkende rit worden meegegeven. Op basis van deze informatie kan via een toewijzingsdisplay worden aangegeven (t.b.v. de chauffeur) vanaf welk perron de bus moet vertrekken, c.q. dat de bus eerst naar de buffer dient te gaan (omdat de omloopgegevens geen onderdeel uitmaken van koppelvlak 1, wordt van het IVS in de bus verwacht dat de vertrekkende rit wordt aangegeven.

4.3 Session layer

The session layer handles all functionality for connection and connectionless communication. Because only messages will be send and received, no data is added to the message of the presentation layer. Therefore, the layer will be empty.
If connections are necessary in the future than this will be implemented in this layer.

A message from the ‘Presentation layer to this layer will consist out of the destination address, priority (high or normal) and the message contents as specified in the ‘Presentation layer’.
A message from the ‘Transport layer’ to this layer will consist out of the source address and the message contents as specified in the ‘Presentation layer’.

4.4 Transport layer

The transport layer handles splitting messages. Furthermore this layer creates or uses a network connection on behalf of the session layer. Because the session layer will be connectionless and the size of messages will never exceed the maximum as supported by the network layer the transport layer will be empty.

A message from the ‘Session layer to this layer will consist out of the destination address, priority (high or normal) and the message contents as specified in the ‘Session layer’. (Because the ‘Session layer’ adds no extra data to the message it will be the same as in the ‘Presentation layer’).
A message from the ‘Network layer’ to this layer will consist out of the source address and the message contents as specified in the ‘Session layer’. (Because the ‘Session layer’ adds no extra data to the message it will be the same as in the ‘Presentation layer’).

4.5 Network layer

The network layer handles routing messages to the destination. Because the protocol handles only direct communication between the source and destination there is no routing involved and so this layer will be empty.

A message from the ‘Transport layer’ to this layer will consist out of the destination address, priority (high or normal) and the message contents as specified in the ‘Transport layer’. (Because the session and transport layer adds no extra data to the message it will be the same as in the ‘Presentation layer’).
A message from the ‘Data link layer’ to this layer will consist out of the source address and the message contents as specified in the ‘Transport layer’. (Because the session and transport layer adds no extra data to the message it will be the same as in the ‘Presentation layer’).

4.6 Data link layer

The data link layer will receive a message from the network layer containing the destination address, priority (high or normal) and the message contents. It will send a received messages to the ‘Network layer’ containing the received data and the source address.

The data link layer will support the following functionality:
1. Send the data to the destination.
2. Retry on send failure detected by an timeout or Nak message.
3. Sending an Ack or Nak on receiving a message.
4. Encapsulate the message in a start header, end header and adding CRC to check the validity of a message.
5. Will handle messages with high priority such that the probability of arriving without a delay will be higher.

4.6.1 Message specification

The data link layer will send three different messages. It can be a data message, an acknowledge message or a not acknowledge message. The contents of these messages are described in the following three paragraphs.

Fieldname	*Size (in bytes)*	*Range*	*Description*
Start character <SYN>	1	(0x16)	Each message will start with this value.
Message type	1	(0x01) (0x06) (0x15)	Meaning of this value is that this is a data message. <SOH> (0x01) a data message. <ACK> (0x06) an acknowledgement message. <NAK> (0x15) a not acknowledgement message.
SID Destination	2	0..65535	Specifies the destination of this message.
SID Source	2	0..65535	Specifies the source of this message.
Sequence number	1	0..255	A sequence number used to distinguish at the receiver side between different messages.
Length	1	0..255	The length of data field (without expansion/character stuffing). So the maximum number of databytes send is the length + 12 bytes. If there is no data field, which is the case when the message type is ACK or NAK this field should have the value 0.
Crc1	2	0..65535	The CRC over the fields: message type, destination, source, sequence number and length.
Data	0..255	0..255	The data. As it is received from the Network layer. (If length is 0 then this field will not be part of this message).
Crc2	2	0..65535	The CRC over the field: Data. (If length is 0 then this field will not be part of this message).

Every message will start with an unique sequence of characters. Namely starting with a <SYN> character followed by a <SOH>, <ACK> or <NAK> character. When this is detected the receiver knows that this is the start of a message.

Explanation:

Start character <SYN>

There is a possibility that the <SYN> followed by an <SOH>, <ACK> or <NAK> character is also part of the rest of the message. In that case the receiver will incorrectly assume that it is the start of a message. To solve this problem each <SYN> character, which is not the start character, should be replaced with two <SYN> characters. This is called character stuffing. On receiving two <SYN> characters these should be replaced with one <SYN> character. This should be done on each character that is received except for the start character. The extra added characters should NOT be taken in to account in the length field or in the CRC calculations.

Message type

The start character and the message type should be used as starting point of a message whenever this sequence is detected that should be seen as starting a new message. If this happens during receiving a message than that should be used as new starting point of a message. These rules should be applied to the received data after character stuffing is done as described in the previous paragraph.

System identification (SID)
Each system or system port combination will have a SID. The SID will be used by the receiver to check if the message was meant for that receiver. The receiver will only react on messages with SID of the receiver. Messages with another SID will be ignored.
It is allowed that one receiver will handle messages for different SID numbers. This can be used to send the message internally to the correct system. For the sender this will be seen as if there is a receiver for each SID.

When an ACK or NAK message is send the destination and source fields will have respectively the value of the source and destination fields of the message that is acknowledged or not acknowledged.

The situation that in a single radio coverage area more systems use the same SID number should be prevented. This results in a numbering plan for SID-numbers, in which each moving (vehicle) system in the Netherlands has a unique SID-number. In Appendix C on page 29, the current numbering plan and assignments are presented.

Sequence number
The sequence number is used by the receiver to know if a received message is a new message or message send again due to transmission errors. It will be handled as a new message when the sequence number for the same source is not the same as the last received message. If there is never a message received from a specific source the first received message with any sequence number will be handled as a new message. This will be also the case when the last received message is older than 5 minutes. This implies that when a message is received with the same sequence number as the previous message, from the same source and within 5 minutes, the message should be ignored. In this case an acknowledge message still should be send.
The sender will increase the sequence number with 1 for each new message for each destination. When 255 is reached the sequence numbering starts again at 0.

The acknowledgement and not acknowledgement message will return the sequence number of the message which is acknowledged or not acknowledged.

Length
The length of the message. The total size of the message will be the length + 12 bytes for the extra data. When the length is 0 then there will be no CRC2 in the message and the message length will be 10 bytes.

CRC calculation
In the message there will be two CRC calculated. CRC1 is calculated over all fields up to the CRC1 without the start character. CRC2 is calculated over all bytes of the data field.
Note: the extra characters <SYN> added for the character stuffing will not be used in the CRC calculation.

The CRC used is the standard CRC-CCITT X-modem polynomial: x^16+x^12+x^5+1. The algorithm to calculate the CRC can be found in Appendix B.

4.6.2 Protocol specification

This protocol[1] specification describes the way stations co-ordinate their access and use of the shared communication channel. So all stations, the vehicles and road systems, that access the communication channel should use this protocol.

The protocol is designed to avoid collisions as much as possible. That means that when the channel is busy other stations will not send any data.

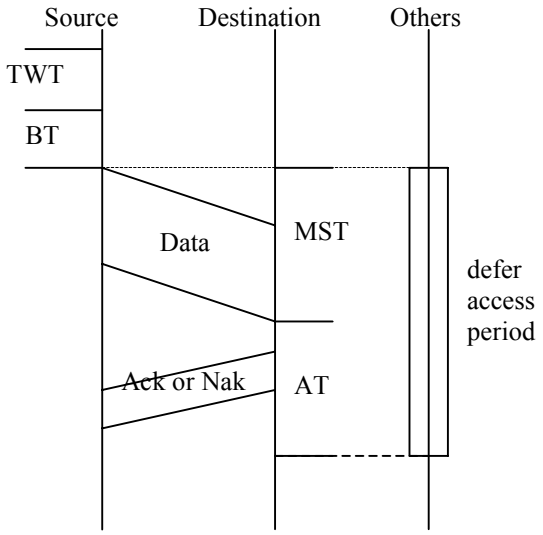


Figure 6 Data transmission

Figure 6 illustrates the timing during data transmission. The following procedure to send a data message should be followed:

When a station needs to send a data message and there was a transmission of this station in the previously 500 milliseconds it should wait 500 milliseconds since the last transmission ended. This period is called 'transmission wait time' (TWT). Then the station should wait until the channel is free according to the rules for the 'defer access period' (DAP), see for a description page 24. When the channel is free, it should wait an additional backoff time. This backoff time (BT) is a random time with a maximum value of 1000 milliseconds (MBT). This will be used to avoid that all stations waiting for an idle channel will start sending at the same moment. After waiting the backoff time it should be checked that the channel is idle, if that is the case then sending should immediately start. The period used to send a data message may not be longer than the 'maximum send time' (MST) which is 1500 milliseconds.

When a message should be send with a high priority, as used for the emergency services the maximum backoff time is 100 milliseconds (MBTHP). This will give the emergency services a higher probability that the message can be send without a delay and so fulfilling the requirement for a high priority.

After the data message is received at the destination the destination has an 'acknowledge time' (AT) to send the ACK or NAK message. This 'acknowledge time' (AT) is 200 milliseconds.
On receiving the data message the CRC1 field should be checked if it is correct than the data part should be

[1] The protocol here described is based on the Media Access Protocol of IEEE 802.11 wireless LAN.

checked by verifying the CRC2. When both CRC1 and CRC2 are valid, an ACK message should be send to the sender. The ACK message should also be send when the length is 0 and CRC1 is valid. When the CRC1 is valid and the CRC2 is invalid a NAK message should be send. When the CRC1 is invalid no message should be send because it isn't sure what the source address is.

The other stations will not send any data as long as the channel is busy and after it becomes idle it will wait the 'acknowledge time' or until the ACK or NAK message is received. This period is called the 'defer access period' (DAP).

When the sender receives a NAK it has to send the same message again. When there is no ACK received in the 'acknowledge time' the message should also be send again. The maximum number of retries is 3.

The following parameters are mentioned in the previous section:

Abbreviation	*Full name*	*Default value*
MBT	Maximum backoff time	1000 milliseconds
MBTHP	Maximum backoff time, high priority	100 milliseconds
AT	Acknowledge time	200 milliseconds
NR	Number of Retries	3
MST	Send time	1500 milliseconds
TWT	Transmission wait time	500 milliseconds

It should be possible to change these parameters.

In the 802.11 specification also the hidden terminal problem[1] is recognised and solved with the protocol. This solution will only help if the messages are large. The priority request messages are relative short. Implementation of the hidden terminal problem will make the protocol more complex and will result in a lower net capacity due to extra overhead messages. The hidden terminal solution of the 802.11 protocol will not be integrated in the KAR-protocol.

4.6.3 Minimum performance requirements

The minimum performance requirements are:
20 successful messages per minute send by 20 stations within a single area where the stations can receive each other. This will result in 10 arrivals and departures at a VRI per minute.
90 % of the message will be received correctly within 1 second and that 99 % of the messages will be received correctly within 3 seconds.

[1] The hidden problem will occur in the following situation. Suppose that station A want to transmit a message to station B. Suppose also that station C want to transmit a message to station B. It is also possible that station A and C can not hear each others transmissions. In that case it is possible that at station B a collision occurs when both stations are sending at the same moment. This problem is recognised in the IEEE 802.11 protocol and solved with the following protocol. When a station wants to send a data messages it first sends a short Request To Send (RTS) message indicating the duration of the data message to send and the ACK messages. The station that receives the RTS will respond with a Clear To Send (CTS) also containing the requested duration and give the requester explicit permission to send. All other stations hearing the RTS or CTS know about the pending data message and will not send during the specified time to avoid interfering with the transmission.
This last protocol has two advantages. First all stations at the transmitter side will receive the RTS and all stations at the receiver side will receive the CTS. So all stations within the range of the transmitter and receiver will hold back transmissions and thereby avoiding collisions. Secondly because the RTS and CTS messages are short the chance that the these message will be corrupted by a collision is lower because the size of the message is small. Note that when the RTS and CTS messages are successful transmitted no more collisions will occur.

4.6.4 Protocol throughput

This throughput as described in this chapter need to be calculated and verified by a simulation. The KIS project team will determine this together with TNO or TU-Delft. The result of this research should at least fulfil the requirements as stated in paragraph 4.6.3 “Minimum performance requirements”.

4.7 Physical layer

This physical layer transmits and receives the data using radio communication. The physical layer will be implemented by a modem. The modem will communicate with the ‘data link layer’ via a RS232 port. See for the full specification the documents ‘User requirements and test results radio modem DRIS ‘[RADIO-MODEM] and ’Functional specification for a radio modem for use with the KAR Protocol’ [RADIO-MODEM2]. It is strongly recommended to specify the centre frequency of 428,925 MHz for the radiomodems. Within the range of this centre frequency, which is set in the factory, all country wide KAR-frequencies can be reached within ± 1 MHz (within this reach the change of frequency can be controlled by the vehicle system). Each owner of road systems and public transport companies should request the RDR for a license.

A licence, as specified by the RDR, will contain the following requirements:

- The used frequencies, these will be in the UHF band and specified by the licence of the RDR.

- Extra regulations as specified in the licence:

    - Identification
      Identification of a transmission should be done with the identification name or file number.

    - Channel free condition:
      The transmitter may only be activated when the transmission channel is free. For this purpose the receiver should have the possibility to detect a transmission and give some signal that the channel is busy or free. The level for carrier-sensing should be set to such a level that there will be no interference with other users of the same channel.

    - Time limitations:
      To avoid that the channel can not be used by other users the maximum transmission time is limited to 2 seconds. The maximum send time for the longest message according the message specification is 1220 ms (speed 9600 bps). So there is no need to control the maximum transmission time in this KAR-protocol.

Transmission requirements which are not part of the licence, but need to be defined as part of the KAR-protocol

- Frequency for traffic light priority messages: 429,8500 MHz (as specified in the RDR-licence)
- Frequency for stop message (type 2): 427,9875 MHz (Vehicle tracking frequency)
  Communication speed on serial interface: 19200 bit/s
- 8 databits
- 1 stopbit
- no parity
- no forward error checking
- transmission power: 100 mW

The transmission power should be as low as possible, in order to restrict the coverage area (and minimize the risk of collisions with messages for other traffic light controllers). It should be possible to change the transmitter power through the serial RS232 interface. The nominal output power for traffic light priority requests will be default 100 mW (the range will be 1200 meters). Since *Most priority requests will be send at distances between 150 and 350 meter from the traffic light controller, this output power will be enough to cover the required distances.*

The vehicle system computer should control the nominal output power, depending over which distance the message should be sent (attribute 14 in KAR message).

The following table may be used as indication to translate the distance to the needed output power (QLINK 450 Radio modem operating instructions, version 3.1 Wood & Douglas, December 2001):

Power Level	Output Power			Range (km)
	MW (nominal)	DBm (nominal)	Tolerance (dB)	
1	16	12	±3	0.5
2	25	14	±3	0.6
3	40	16	±3	0.7
4	63	18	±1.5	0.9
5	100	20	±1.5	1.2
6	158	22	±1.5	1.5
7	251	24	±1.5	1.9
8	398	26	±1.5	2.4
9	631	28	±1.5	3.0
10	1000	30	±1.5	3.7

The range is calculated with the following assumptions:
- Line-of-sight between the transmitter and the receiver
- 0dB gain antennas at the transmitter and the receiver
- 20dB environmental and fade margin
- Forward error correction not enabled.

For the Satel 3AS OA modem the following power levels may be used (Satel 3AS OA Radio modem user Guide)

Power Level	Output Power	
	mW (nominal)	dBm (nominal)
1	10	10
2	20	13
3	50	17
4	100	20
5	200	23
6	500	27
7	1000	30

Radio requirements
Modulation: 4LFSK
Receiver sensivity: < -108 dBm < 10E-4
Frequency stability: ± 1,8 kHz
Communication speed over air: 9600 bps (current maximum at Dutch 12,5 kHz channel spacing)

Appendix A Recommendation for “standard” presentation layer messages contents

The defined standard KAR-message, as defined in paragraph 4.2.1.2, contains 24 attributes, which can be filled in for a local situation, depending on the information needs and used techniques. The receiving system (traffic light controller) should be able to use all attributes. The attribute “used attributes” indicates which attributes will be really used. The functionality of the sending system (the vehicle system) defines which attributes are used.
The message transferred by radio should be as short as possible due to the limited capacity of the radio channel and to minimise the chance of communication errors and collisions.

Based on experience in the current KAR projects (2005), it is recommended to use the following attributes as “a standard” for handling priority requests by buses:
2. Vehicle type (to distinguish HOV and LOV busses)
3. Line number (for logging and checking)
6. Vehicle id
7. Direction at intersection
8. Vehicle status
11. Punctuality [s] (for conditional priority)
13. Actual vehicle speed
14. Distance till passage stop line
15. Driving time till passage stop line
19. Type of command (for activation/deactivation)

It is recommended to use the following attributes as “a standard” for handling priority requests by emergency services:
2. Vehicle type (to distinguish HOV and LOV busses)
3. Company number (Veiligheidsregio: 101 t/m 200)
6. Vehicle id
7. Direction at intersection
9. Priority class
13. Actual vehicle speed
15. Driving time till passage stop line
19. Type of command (for activation/deactivation)

Appendix B Algorithm to calculate the CRC

This appendix contains a c procedure to calculate a CRC.

```
/* CRC_UPDATE() */
/* ------------ */
/* crc_update() calculates the CRC over one byte
 * crc_update() is called by crc_block().
 * CRC calculation according to CCITT. Algorithm of Ir. J. van Dillen.
 * crc_update() returns the calculated CRC.
 */

static word crc_update (word crc, byte b)
{
 word i, x;

 for (i=0; i<8; i++){
   x = b^crc;
   crc >>= 1;
   b >>= 1;
   if (x & 1) crc ^= 0x8408;
 }
 return crc;
}

/* CRC_BLOCK() */
/* ----------- */
/* crc_block() calculates the CRC over a data block.
 * crc_block() uses the method crc_update().
 * crc_block() returns the calculated CRC over the data block.
 */

word crc_block(byte *data, word len)
{
 word crc=0;

 while (len--) crc = crc_update(crc, *data++);

 return crc;
}
```

Appendix C Company numbers and System identification assignments

Company numbers (Attribute 5)

The combination of the attributes 2 (vehicle type), attribute 5 (Company Number) and attribute 6 (vehicle id = grootwagennummer). In the following table the values for attribute 5 (Company number) are defined:

Value KAR attribute 5	**Description**
0	No information
1 t/m 200	Public Transport Companies
1	Arriva
2	Veolia
3	Connexxion, Hermes (incl. GVU, Novio, Stadsvervoer NL)
4	GVB Amsterdam
5	HTM
6	RET
7	NS
8	Syntus
9 – 10	Reserved
11 – 19	Reserved for subcontractors Arriva
20	TCR (Taxi Centrale Renesse)
21 – 30	Reserved for subcontractors Veolia
31 – 40	Reserved for subcontractors Connexxion
41 – 200	Reserved
201 t/m 255	Emergency Services
201	Emergency Service vehicles veiligheidsregio 01
202	Emergency Service vehicles veiligheidsregio 02
….	
255	Emergency Service vehicles veiligheidsregio 55

Numbering scheme “Veiligheidsregio”:

Nr.	**Name veiligheidsregio**	**Nr.**	**Name veiligheidsregio**
01	Groningen	14	Gooi en Vechtstreek
02	Friesland	15	Haaglanden
03	Drenthe	16	Hollands Midden
04	Ijsselland	17	Rotterdam – Rijnmond
05	Twente	18	Zuid-Holland Zuid
06	Noord- en Oost Gelderland	19	Zeeland
07	Gelderland – Midden	20	Midden- en West Brabant
08	Gelderland – Zuid	21	Brabant Noord
09	Utrecht	22	Brabant Zuid-Oost
10	Noord-Holland Noord	23	Limburg – Noord / Midden
11	Zaanstreek – Waterland	24	Limburg – Zuid
12	Kennemerland	25	Flevoland
13	Amsterdam – Amstelland		

SID-numbers

The situation that in a radio coverage area more systems use the same SID number should be prevented. This results in a numbering plan for SID-numbers. This numbering plan is based on the following starting points:

- The road systems will get a KAR-SID number in the range 1 –9999. Normally each road owner may use the same numbers as used in the numbering scheme of the traffic light controllers. With neighbourhood road owners the uniqueness of the SID-numbers in the radio coverage area should be verified.
- For the unique identification of vehicles ranges of SID numbers above 10.000 are used. The public transport companies are allowed to assign the SID's within this range. It is suggested to use the vehicle-id (grootwagennummer) added with a standard value to get a SID-number in the assigned range.

The following table gives the range that may be used by the assigned user. The user should take care that the SID number is never used more than once in the same radio coverage area. See also the SID description in paragraph 4.6.1.

Range	**User**
0	Reserved
1- 10000	Road systems
10001 – 20000	Connexxion, Hermes (GVU, Novio, Stadsvervoer Nederland)
20001 – 30000	Arriva
30001 – 40000	Veolia
40001 – 45000	GVB Amsterdam, RET, HTM rail
45001 – 45999	GVB Amsterdam bus
46001 – 46999	RET bus
47001 – 48000	HTM
48001 – 49000	Syntus
49001 – 50000	Reserved
50101 – 52999	Reserved for Emergency services
53001 – 53999	Police, all regions
54001 – 54999	Fire Brigade (Brandweer), all regions
55001 – 56000	ambulance / huisartsenposten
65532	Reserved

Note:

[1]) Suggested is that public transport owners uses the vehicle id of the vehicle as a SID number. If necessary a value should be added or subtracted from the vehicle id to get a SID number that is in the assigned range.

[2]) Because these users are not a single organisation they have to negotiate with the other organisations that use the same range to avoid that a SID is never used more than once in the same radio coverage area (a circle with a radius of 10 km)

Appendix D Recommendation for handling specific situations

Priority request at stops in the announcement area of a traffic light controller

Definition:
Announcement area: the area between the stopline of the traffic light and the announcement point.

If there is a stoppoint in the optimal announcement area of a Traffic Ligth (VRI), the actual sending of the KAR message may be made conditional. Possible conditions are: The door close signal or the push of a button by the driver (trigger Start Door Close At Stoppoint or PRQM: Priority ReQuest Manual confirmation)

On a 'SDCAS' or 'PRQM' triggerpoint an indicator (for example " over loop lamp ") will show to the driver that manual priority request is allowed. If the button is pressed, the KAR-message is sent. At the opening of (one of) the doors, the indicator is put out (if the message is not sent already). At the closing of the doors, within the stop window, the indicator will light up again (for the PRQM trigger). If the button is pressed OR when the bus leaves the stop window, the KAR message is sent and the indicator is put out.

When a 'SDCAS' activationtype is used, the KAR message is sent automatically at the start door close signal (the indicator will not light up again). The PRQM activationtype instead of SDCAS is recommended for so called timing stops (where the bus may not directly depart after the boarding and alighting) of long stops (where the bus may stop a second time for the boarding of passengers)

Reset of manual priority request indicator
If the stop point is passed AND the driver didn't sent the priority request manually, the message is sent automatically when the bus leaves the stop window OR when the bus stands still for more than 3 seconds (with doors closed). When the next PRQA-trigger (in most situations the deactivation KAR message) is sent, a remaining previos PRQM or SDCAS trigger will be reset.

Opening of doors after the sending of a priority request
If the bus stops for boarding or alighting passengers in the announcement area after the sending of the priority request, the opening of the doors should be used to send a "deactivation" priority request. At the start door close a new priority request message for the same crossing, phase cycle is sent.

KAR- stop message (message type 2)

The KAR Stop message is sent at arrival, departure or passage of a stop point or stop area to which a Passenger Information Unit (with a KAR adress is assigned).

Definition
Stop window: the area around a stop point, a number of meters before the stop post and a number of meters after the stop post (stop post is imaginary line where the front site of the first bus stops, mostly the point where the stop post is located). When it is sure the bus has passed the stop window, activations may be triggered. The stop window is defined in the software of the vehicle system and depends on the positioning system used.

The KAR Stop message is sent under the following conditions:

- At arrival on a stop point (door open within stop window), also at the arrival of the first stop (begin stoppoint of a journey)
- A departure/passage of the stop point (leave of stop window)
- At a pre-announcement point. This is a point with the “AABS”-trigger, AABS = Automatic Announcement Bus information System

Extra triggers, alleen van toepassing indien KAR ook wordt gebruikt voor Voertuig volgen (Bijv. Zuidtangent anno 2006), in deze situaties wordt (nog) geen gebruik gemaakt van TMI koppelvlak 6 voor voertuig volgen
- When the vehicle gets a delay (stand still or speed lower than x km/h during {60 | 1..n}seconds) at a stop point or in between stop points. If the vehicle is still at the begin stop point {60 | 10..n}seconds after the timetabled departure time a delay message should be sent. Type of command ‘delay (between stops) or stand still at stop point’
  At the end of the delay a new stop message is sent with the actual punctuality.

A delay message (or end of delay message) is sent to the Passenger Information unit related actual stop point (this is the next stop point the bus will pass). If no Ack is received from this passenger Information Unit, the message is sent again with the maximum output power (1 W). If again no Ack is received (for instance because de passenger information unit is without radio reach), the procedure is repeated after 60 seconds. This until an ACK-message is received.

For the Zuidtangent, where the KAR-network is used as vehicle monitoring system, an extra cycle is used:
A delay message (or end of delay message) is sent to the Passenger Information unit related actual stop point (this is the next stop point the bus will pass). If no Ack is received from this Passenger Information Unit, the message is sent again with the maximum output power [1 W]. If again no Ack is received (for instance because de passenger information unit is outside the radio reach), a message is sent to the passenger information unit related to the last stop point passed. If this attempt also fails, the procedure is repeated after {60 | 1..n} seconds. This until an ACK-message is received.

Content of attributes at different situations for sending the KAR stop-message

Nr	Opt	Attribute	Arrivalstop n Value	Departure passage stop n	Pre-announcement point between stopn – 1 and stop n	Delay between stop n – 1 and stop n
		Adress message (header)	Address n	Address n	Address n	Address n, if no ack, than address n – 1
	V	Type of message	2	2	2	2
		Used attributes	→	→	→	11111110111101001010110043210987654321098765432121
3	V	Line number PT (internal line number)	TM	TM	TM	TM
6	O	*Vehicle id*	IVS	IVS	IVS	IVS
8	V	*Vehicle status*	2	1	1 of 4	1 of 4
11	V	*Punctuality [s]* - - early (<0) - + late (>0)	IVS	IVS	IVS	IVS
13	V	Stop point id last stop passed	Id n - 1	Id n	Id n – 1	Id n – 1
14	V	*Distance since last stop point* [m]	From n -1	From n	From n – 1	From n – 1
15	O	*Stop time at last stop*	At n – 1	At n	At n – 1	At n – 1
16	V	Journey number	TM'	TM	TM	TM
17	V	Type of Journey or Fortify seq number	TM Default '0'	TM Default '0'	TM Default '0'	
19	V	*Type of command*	1	2	3	0 – no information
20	O	Actual Stop point id	N	-	-	- .
22	O	Boarders at last stop	At n – 1	At n	-	-
23	O	Alighters at last stop	At n – 1	At n	-	-
24	O	Occupancy after last stop	After n – 1	At n	-	-
		Total				

Explanation of abbreviations in the table:
TM = Source of the content is the planning database (Transmodel NL)
IVS = Attribute is available in IVS or is calculated in IVS. The current position of the vehicle on the route, related to stop point n or stop n – 1 is also assumed functionality of the IVS.

' **Journey number**: At the arrival at the begin stop point: journey number of departing journey.
If the end stop point of the previous journey and the begin stop point of the departing journey have the same stop point id/number two message will be sent at the arriving at this stop point:
A message at the arriving within the stop window with the Journey number of the arriving journey
Followed by another message with the Journey number of the departing journey.

Appendix E Practical Protocol implementation

In several projects some practical choices have been made regarding the implementation of the protocol. The access protocol described in par. 4.6.2 is designed to be used primarily for multi channel purposes with automatic channel access. The principle of the access protocol in par. 4.6.2 is that the equipment determines whether or not the channel is, and has been, idle for a certain period by means of carrier sensing. Since the KAR-traffic light priority application will work on one country wide frequency with small radio coverage area's due to al low transmitter power, there is no need to implement a multi channel access protocol., This results in a simpler protocol implementation.

The description of the practical implementation in Dutch can be found in the document "KAR-protocol specification Zuidtangent" (ref: RT493v6). The definitions in this specification are also in English in next section. The presentation layer and the data link layer are not changed, so the practical implementation will always be compatible with other implementations.

In the specification for the Zuidtangent is tried to find a compromise between easy implementation of the protocol, reliable transmission and speed.

Definitions

- **CF** Channel Free. Channel Free. Indicates when a transmission may start, this is when the channel is free
  Remark:
  Two methods can be used to check if the channel is free. Either it is possible to listen to other transmissions with the same modulation or to determine the receive signal strength (squelch). The first method is more reliable in case of disturbance.
  The protocol doesn't describe which method to use, this depends on the characteristics of the used radio modem.
- **TWT** Transmission Wait time. Not implemented in protocol
  This value can be set through a parameter (between 0 and 500 ms). When a station needs to send a data message and there was a transmission of this station in the transmission wait time (0 - 500 ms) it should wait until the end of the transmission wait time.
  Remark:
  It is important that a traffic light priority message will be sent immediately to the traffic light controller after the passing of the activation point, in particular when the first transmission is not received or received correctly. This is the reason why the transmission wait time is not implemented in the Zuidtangent protocol specification.
- **AT** Acknowledge Timeout (default 200 ms). This time starts when the last byte is transferred to the Physical Layer. Within the AT the receiver should give a reply (Ack or Nack). Otherwise a resend of the last message should take place. (a maximum of MR times).
  The propagation time is a part of the AT (2 x ca. 30 ms, depending on the characteristics of the radiomodem) and the process time the receiver needs to decode the message).
- **MST** Maximum Send Time. (2000 ms according to the RDR-license. The maximum time a sender may use for a transmission. According to the message specification and a speed of 9600 bps the maximum send time is 1220 ms. So there is no need to control the maximum send time.
- **BT** Back off Time. A random time between 0 to 400 ms. The random value is generated. The time is used when the channel is occupied when the transmission should start.
- **MR** Message retries. The value can be set through a parameter (default 5 times). The value gives the maximum number of times the transmission will be repeated at the reply of a Nak or the end of the AT.
  In situations where the contents of the message is not valid after a certain time (real-time applications) can be chosen for '0' (zero) retries
- **COR** Channel Occupied Retries. The value can be set through a parameter (default 5 times). This value gives the maximum number of times a BT will be waited after a check that the channel is occupied

Appendix F Selectieve voertuiginformatie in vri's

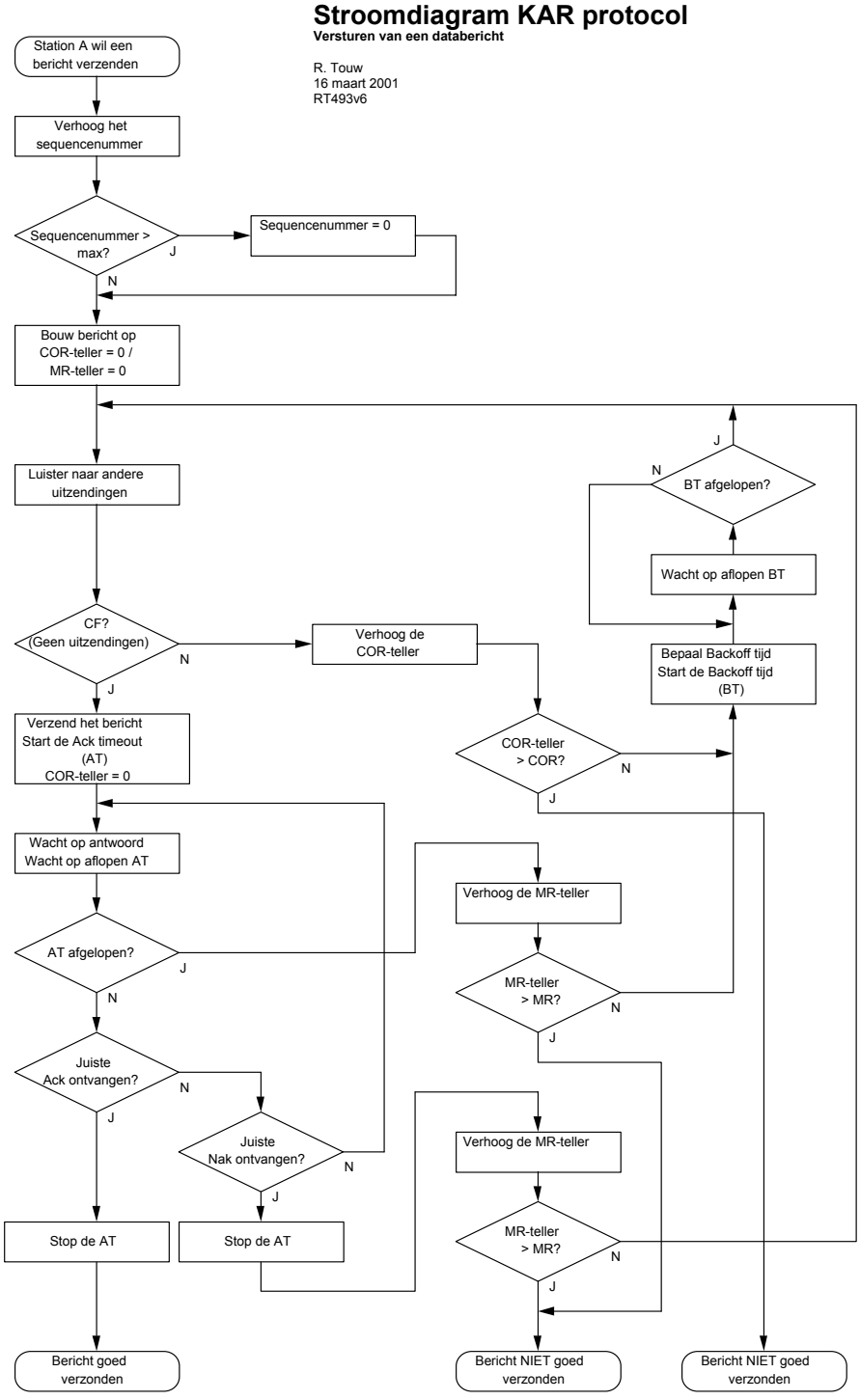
De procesbesturing van de vri-automaat vervult de volgende functies:
- Afhandelen KAR-protocol conform de KAR-Interface Requirement Specificaties, o.a. Checksum controle en beantwoorden met ack/nak.
- Afbeelden van de inhoud van het KAR-bericht op de CVN-C-interface.

Voor de communicatie tussen de procesbesturing en het applicatieprogramma wordt gebruik gemaakt van de buffer Selectieve Voertuiginformatie **CIF_DSI[]** , zoals beschreven in de "Beschrijving van de software-interface tussen het applicatieprogramma en de procesbesturing voor verkeersregeltoestellen" van de commissie C van de CVN, versie 3.1 van 31mei 2005 (of een nieuwere versie).

OF

Indien voor de communicatie tussen de procesbesturing en het applicatieprogramma geen gebruik wordt gemaakt van de Cie C interface, moet het volledige KAR-bericht, zoals beschreven in dit document, dus alle 36 (ook de niet gebruikte) KAR-(deel)attributen, in de applicatieprogramma's aanwezig zijn.

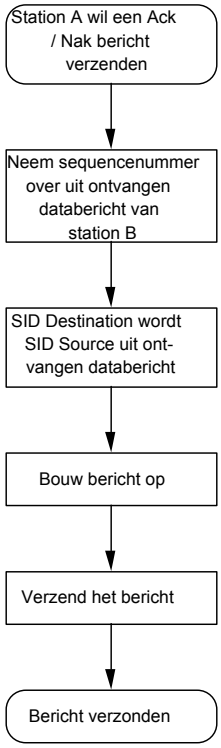
Appendix G Flow charts and timesequence diagrams protocol



Stroomdiagram KAR protocol

Versturen van een Ack / Nak bericht

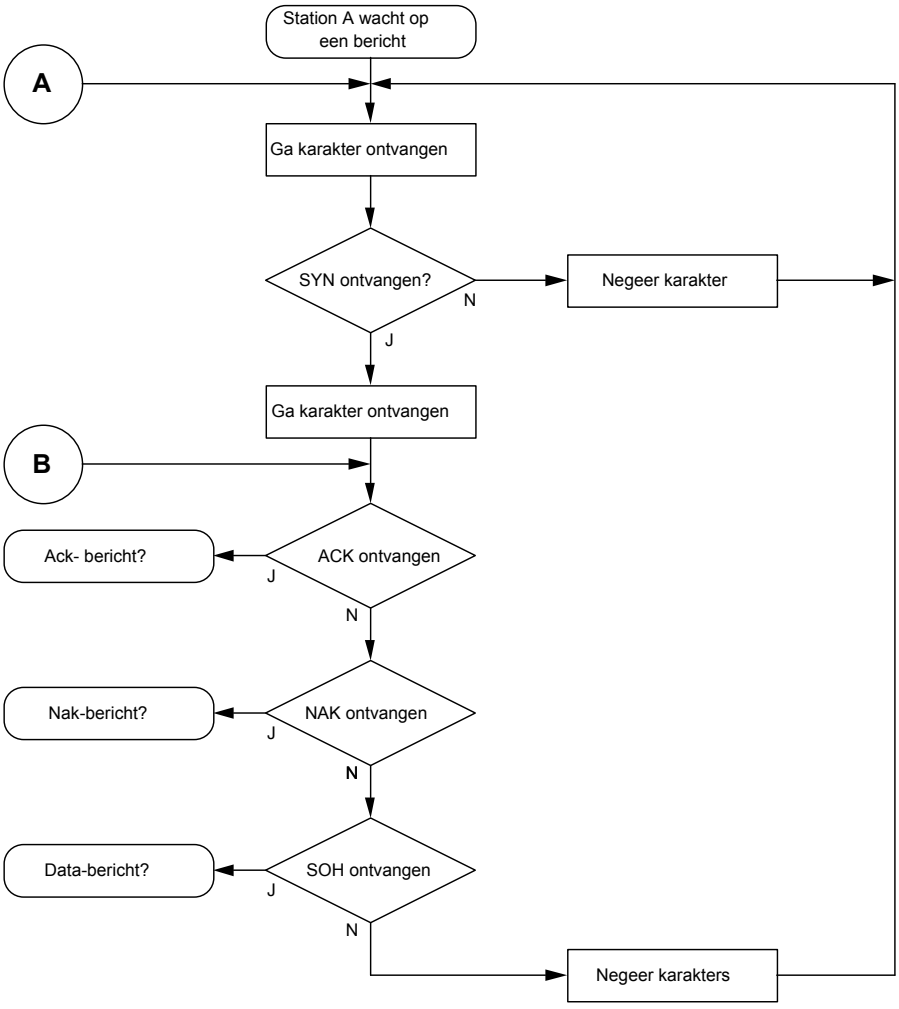
R. Touw
16 maart 2001
RT493v6

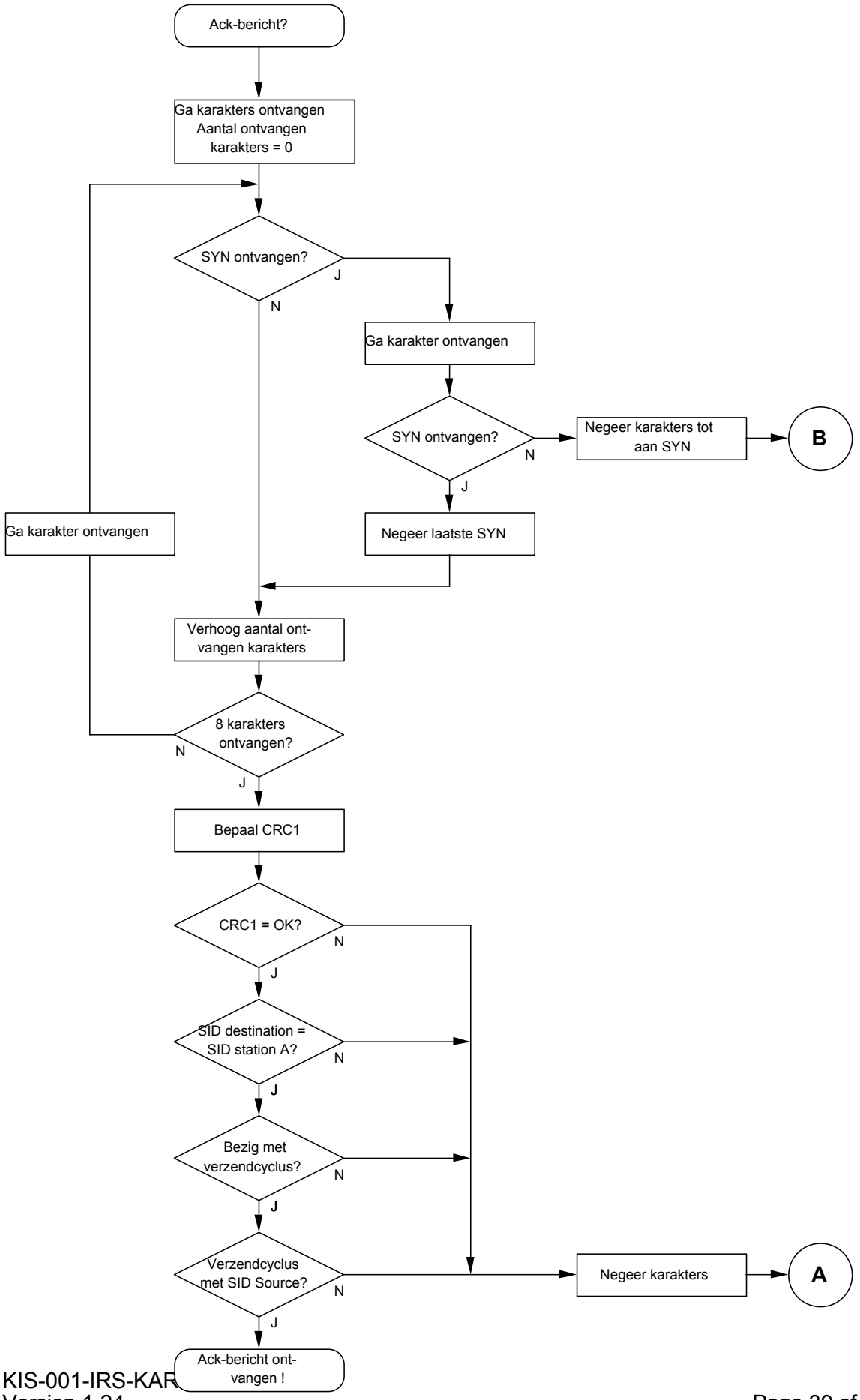


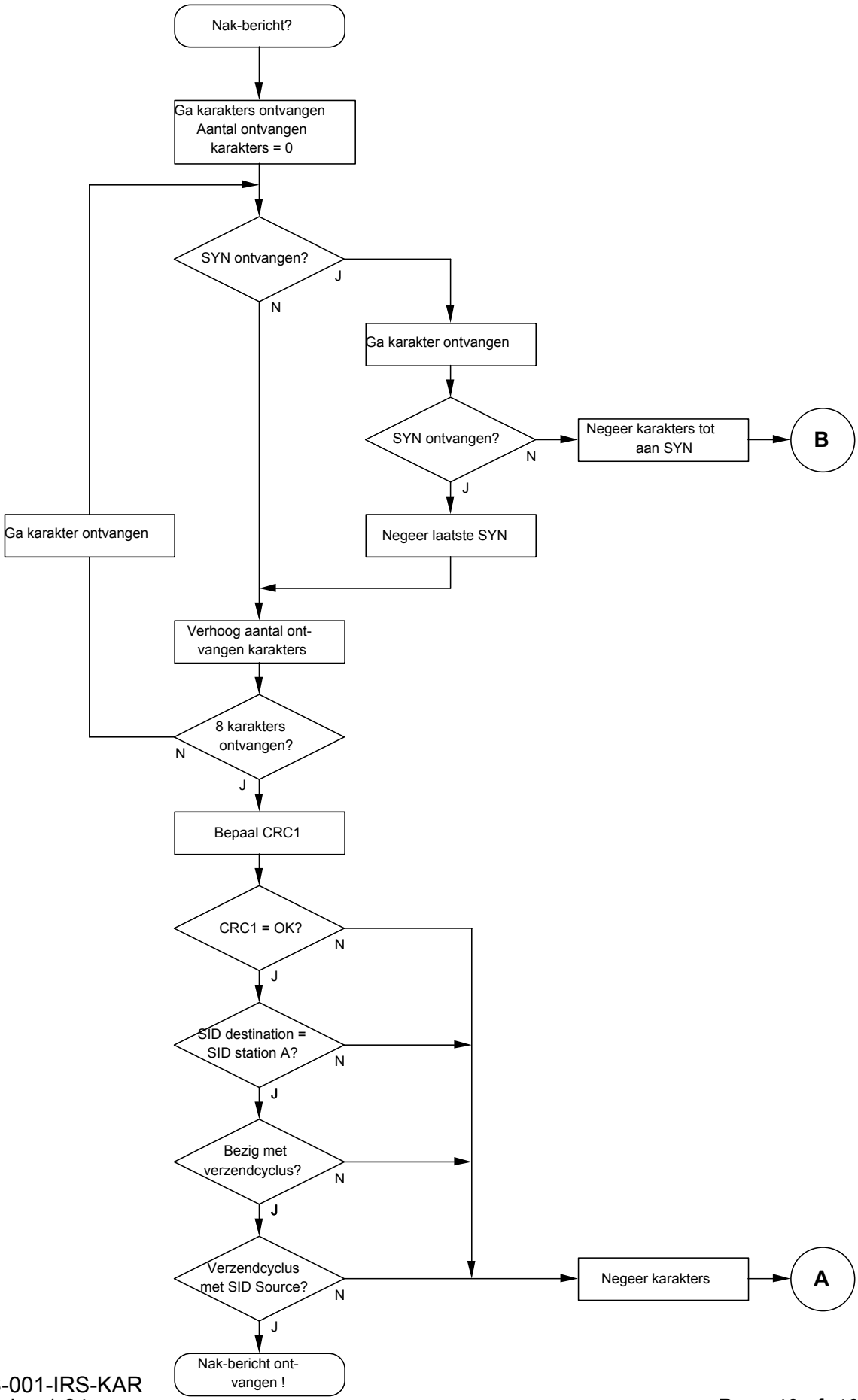
Stroomdiagram KAR protocol

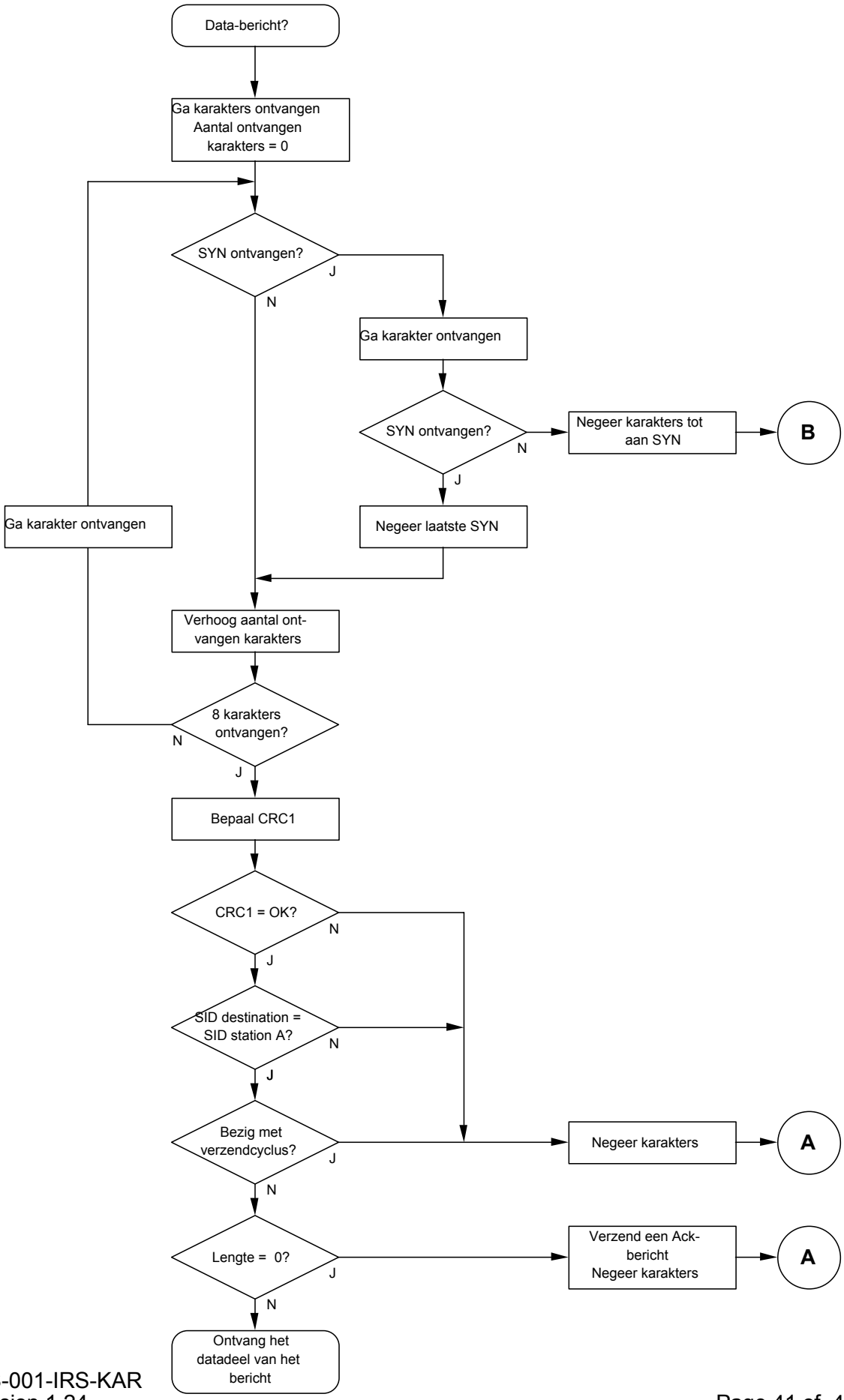
Ontvangen van een bericht

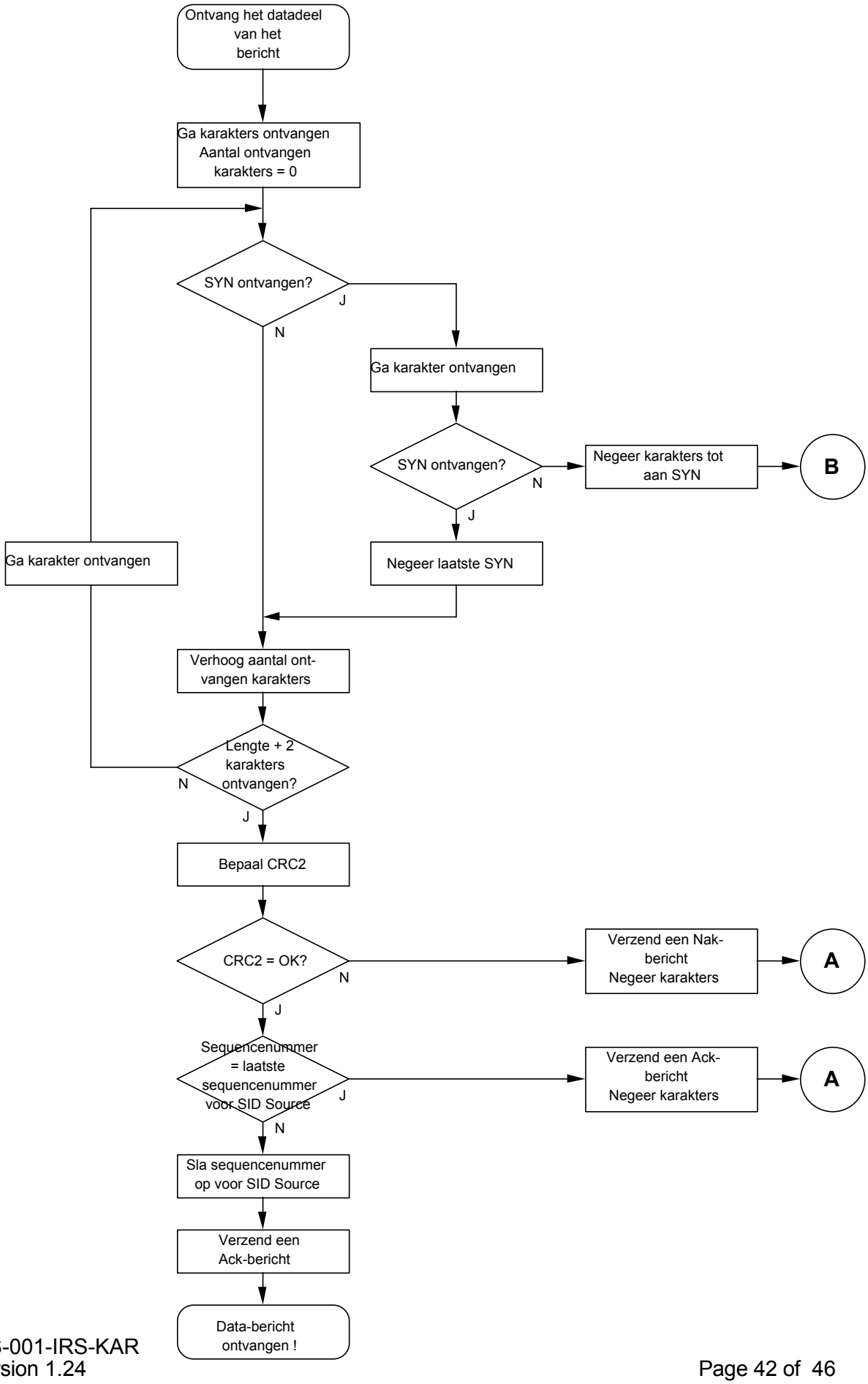
R. Touw
16 maart 2001
RT493v6

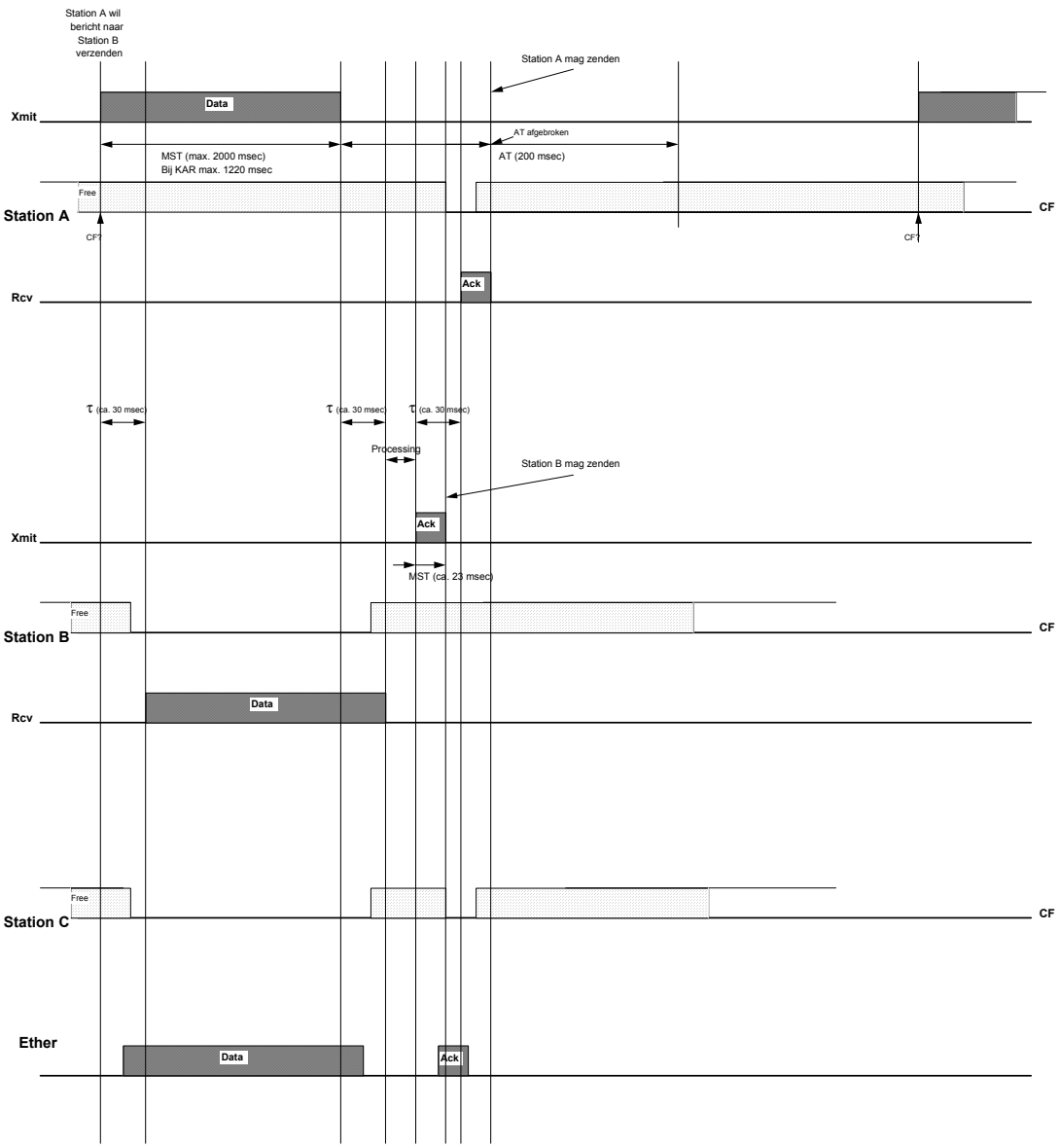


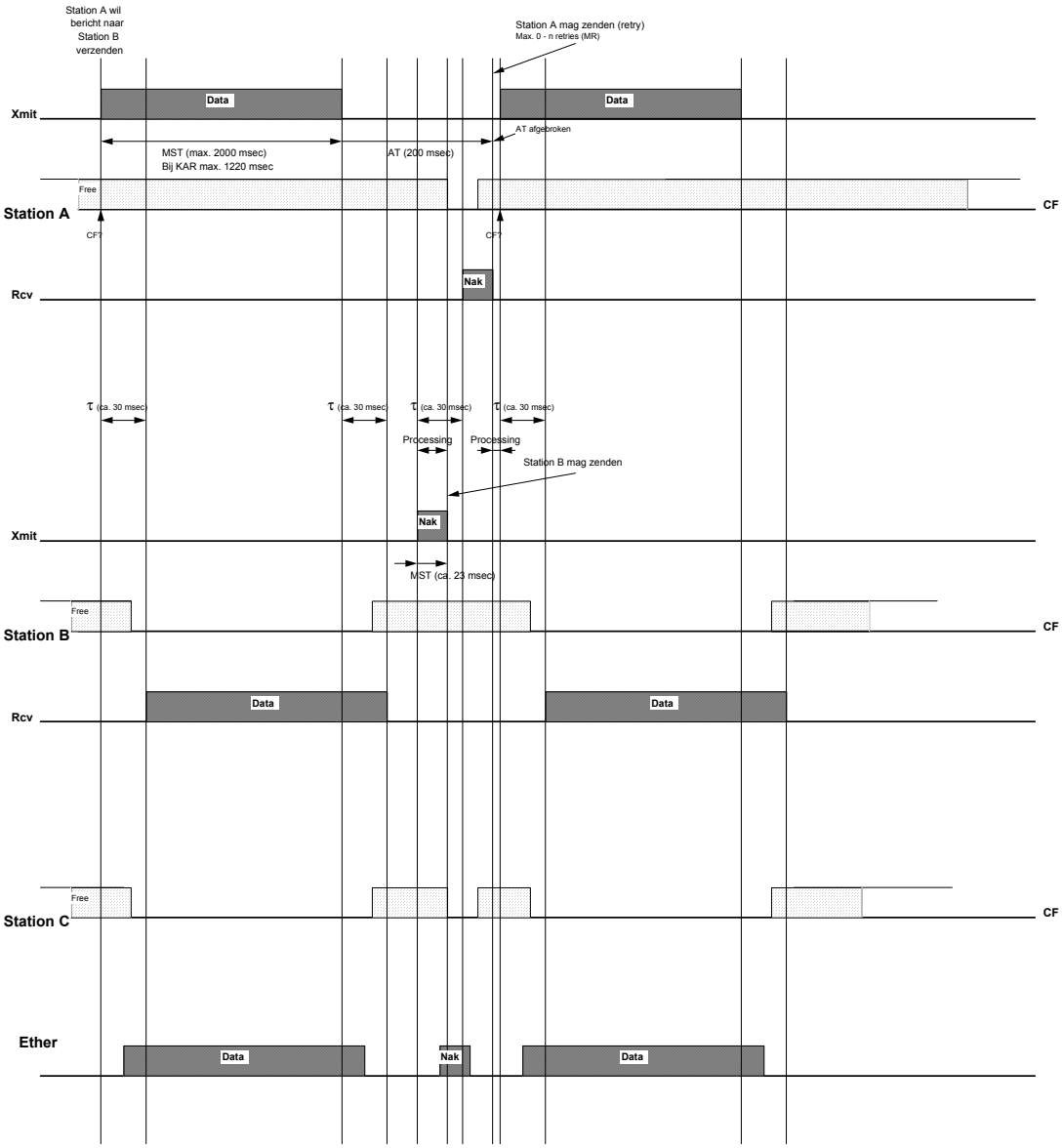

Ack-bericht?
Ga karakters ontvangen
Aantal ontvangen
karakters = 0
SYN ontvangen?
J
N
Ga karakter ontvangen
SYN ontvangen?
N
Negeer karakters tot
aan SYN
B
J
Ga karakter ontvangen
Negeer laatste SYN
Verhoog aantal ont-
vangen karakters
8 karakters
ontvangen?
N
J
Bepaal CRC1
CRC1 = OK?
N
J
SID destination =
SID station A?
N
J
Bezig met
verzendcyclus?
N
J
Verzendcyclus
met SID Source?
N
Negeer karakters
A
J
Ack-bericht ont-
vangen !

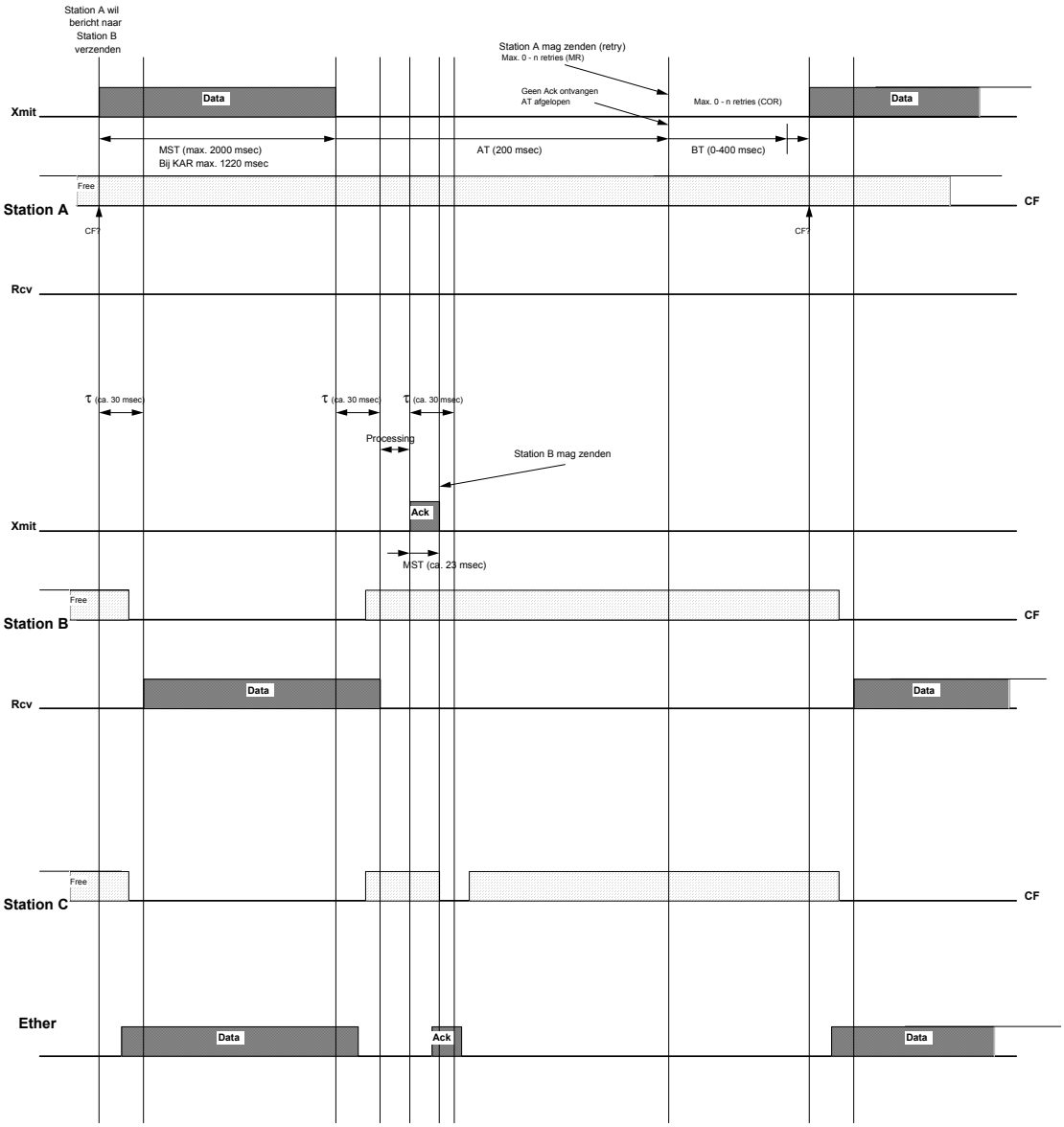

Nak-bericht?
Ga karakters ontvangen
Aantal ontvangen
karakters = 0
SYN ontvangen?
J
N
Ga karakter ontvangen
SYN ontvangen?
N
Negeer karakters tot
aan SYN
B
J
Ga karakter ontvangen
Negeer laatste SYN
Verhoog aantal ont-
vangen karakters
8 karakters
ontvangen?
N
J
Bepaal CRC1
CRC1 = OK?
N
J
SID destination =
SID station A?
N
J
Bezig met
verzendcyclus?
N
J
Verzendcyclus
met SID Source?
N
Negeer karakters
A
J
Nak-bericht ont-
vangen !

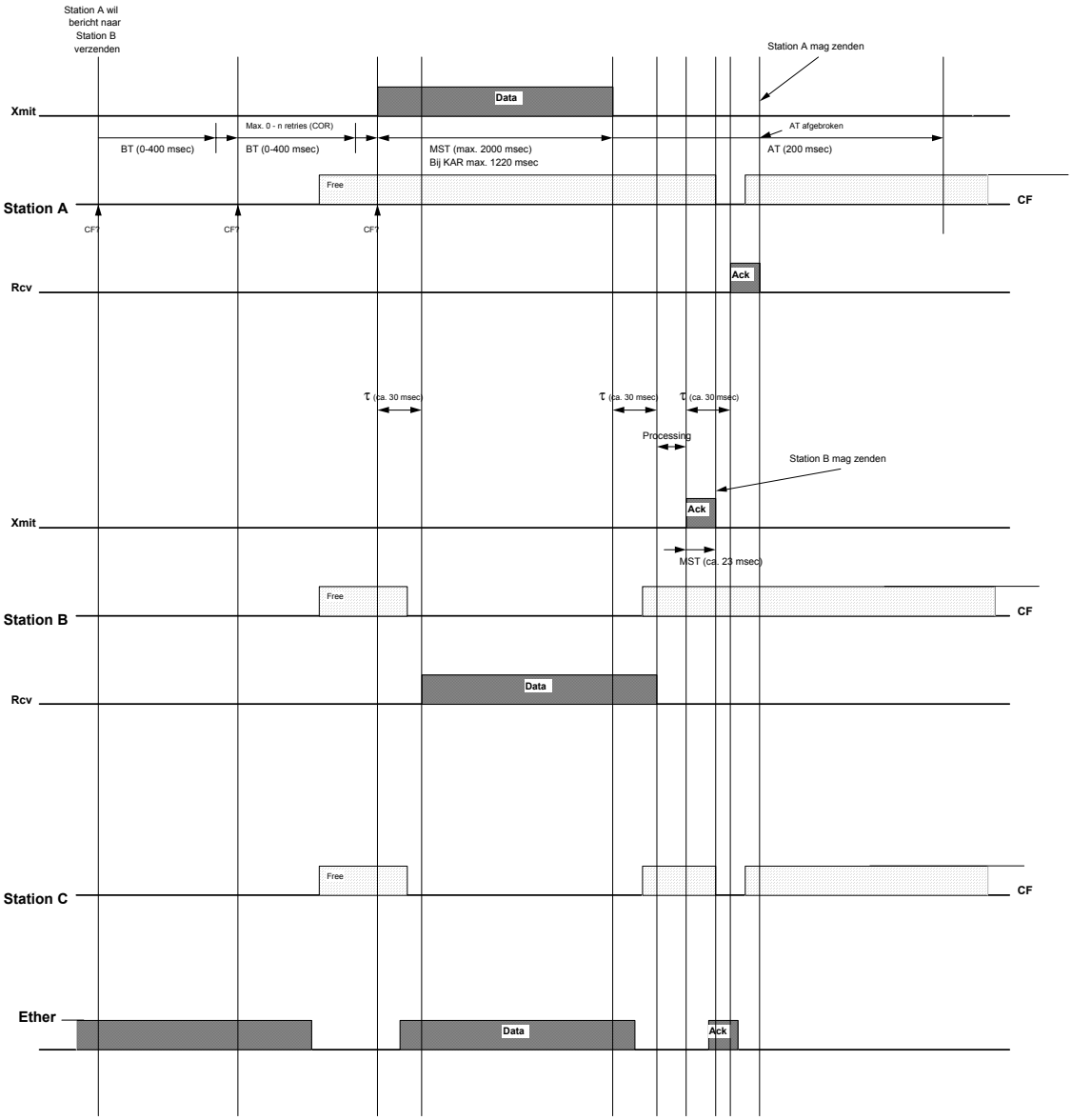

Data-bericht?
Ga karakters ontvangen
Aantal ontvangen
karakters = 0
SYN ontvangen?
J
N
Ga karakter ontvangen
SYN ontvangen?
N
Negeer karakters tot
aan SYN
B
J
Negeer laatste SYN
Ga karakter ontvangen
Verhoog aantal ont-
vangen karakters
8 karakters
ontvangen?
N
J
Bepaal CRC1
CRC1 = OK?
N
J
SID destination =
SID station A?
N
J
Bezig met
verzendcyclus?
J
Negeer karakters
A
N
Lengte = 0?
J
Verzend een Ack-
bericht
Negeer karakters
A
N
Ontvang het
datadeel van het
bericht


Ontvang het datadeel van het bericht
Ga karakters ontvangen Aantal ontvangen karakters = 0
SYN ontvangen?
J
N
Ga karakter ontvangen
SYN ontvangen?
N
Negeer karakters tot aan SYN
B
J
Negeer laatste SYN
Ga karakter ontvangen
Verhoog aantal ontvangen karakters
Lengte + 2 karakters ontvangen?
N
J
Bepaal CRC2
CRC2 = OK?
N
Verzend een Nak-bericht Negeer karakters
A
J
Sequencenummer = laatste sequencenummer voor SID Source
J
Verzend een Ack-bericht Negeer karakters
A
N
Sla sequencenummer op voor SID Source
Verzend een Ack-bericht
Data-bericht ontvangen !


Station A wil bericht naar Station B verzenden
Station A mag zenden
Data
Xmit
AT afgebroken
MST (max. 2000 msec)
Bij KAR max. 1220 msec
AT (200 msec)
Free
Station A
CF
CF↑
CF↑
Ack
Rcv
τ (ca. 30 msec)
τ (ca. 30 msec)
τ (ca. 30 msec)
Processing
Station B mag zenden
Ack
Xmit
MST (ca. 23 msec)
Free
Station B
CF
Data
Rcv
Free
Station C
CF
Ether
Data
Ack


Station A wil bericht naar Station B verzenden
Station A mag zenden (retry)
Max. 0 - n retries (MR)
Xmit
Data
Data
AT afgebroken
MST (max. 2000 msec)
Bij KAR max. 1220 msec
AT (200 msec)
Free
Station A
CF
CF?
CF?
Nak
Rcv
τ (ca. 30 msec)
τ (ca. 30 msec)
τ (ca. 30 msec)
τ (ca. 30 msec)
Processing
Processing
Station B mag zenden
Nak
Xmit
MST (ca. 23 msec)
Free
Station B
CF
Data
Data
Rcv
Free
Station C
CF
Ether
Data
Nak
Data


Station A wil bericht naar Station B verzenden
Station A mag zenden (retry)
Max. 0 - n retries (MR)
Geen Ack ontvangen AT afgelopen
Max. 0 - n retries (COR)
Data
Xmit
MST (max. 2000 msec)
Bij KAR max. 1220 msec
AT (200 msec)
BT (0-400 msec)
Free
Station A
CF
CF?
Rcv
τ (ca. 30 msec)
Processing
Station B mag zenden
Ack
MST (ca. 23 msec)
Station B
Station C
Ether


Station A wil bericht naar Station B verzenden
Station A mag zenden
Xmit
Data
Max. 0 - n retries (COR)
AT afgebroken
BT (0-400 msec)
BT (0-400 msec)
MST (max. 2000 msec)
Bij KAR max. 1220 msec
AT (200 msec)
Free
Station A
CF
CF?
CF?
CF?
Rcv
Ack
τ (ca. 30 msec)
τ (ca. 30 msec)
τ (ca. 30 msec)
Processing
Station B mag zenden
Xmit
Ack
MST (ca. 23 msec)
Free
Station B
CF
Data
Rcv
Free
Station C
CF
Ether
Data
Ack