# Lossless RTCM-SC104 data compression for broadcasting via satellite links

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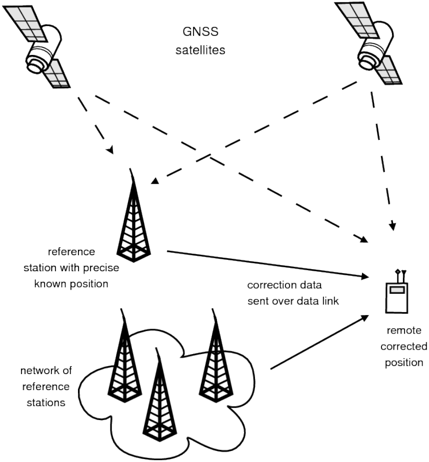
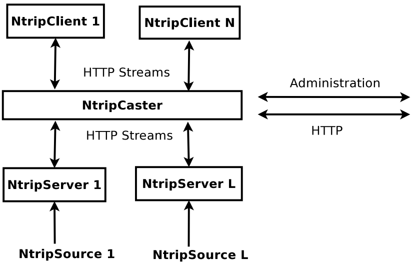
# Error sources in GNSS and relative positioning techniques

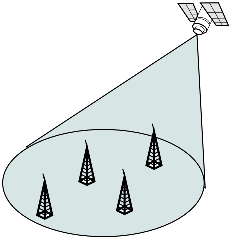



- error sources:
  - satellite orbit
  - satellite clock
  - ionosphere
  - troposphere
- reference stations:
  - precisely located
  - generate periodically corrections
  - single or network

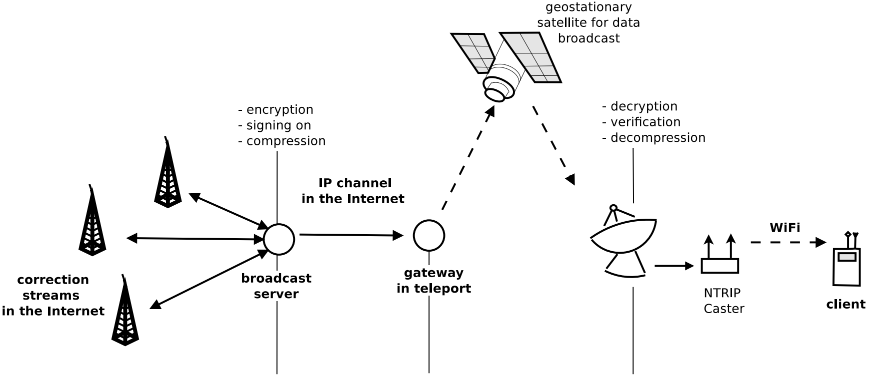
# GNSS data dissemination techniques

- mobile Internet connectivity
  - NTRIP
  - cheap data transmission
  - requires bidirectional connection(authentication)
  - does not provide data security
  - not available in rural areas
- satellite links:
  - continental signal coverage
  - unidirectional ideal for dissemination to the masses because of cheap reception hardware
  - more expensive than terrestrial links, e.g. 512 kbps - 5000 euro per month



# Target system, motivation



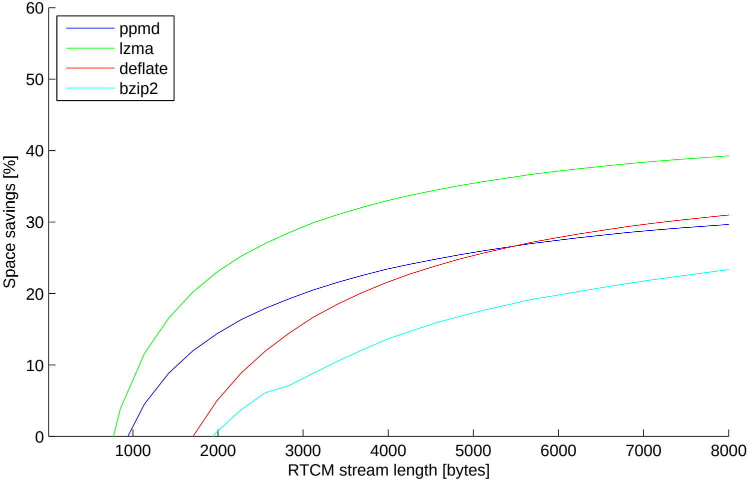

## Motivation

- expensive satellite link capacity
- investigation of RTCM SC-104 format

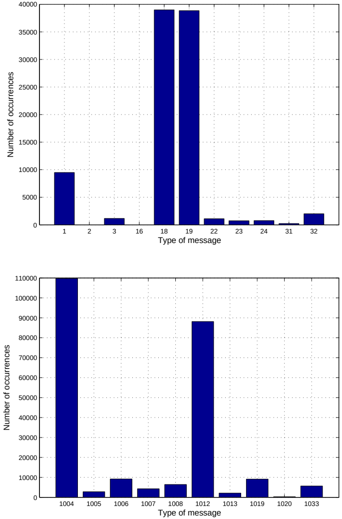
## Expected results

- reduction of transmission costs
- reduction of serialization delay

# Results for universal compression methods

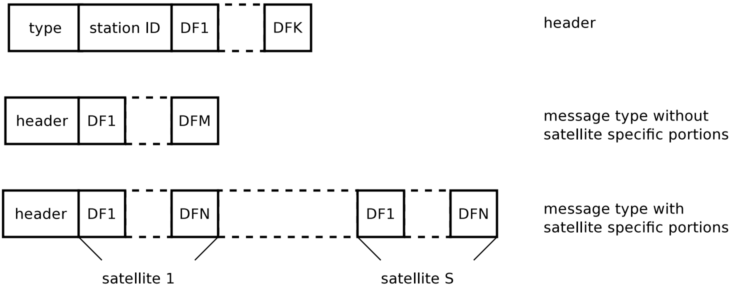


# RTCM SC-104 format usage



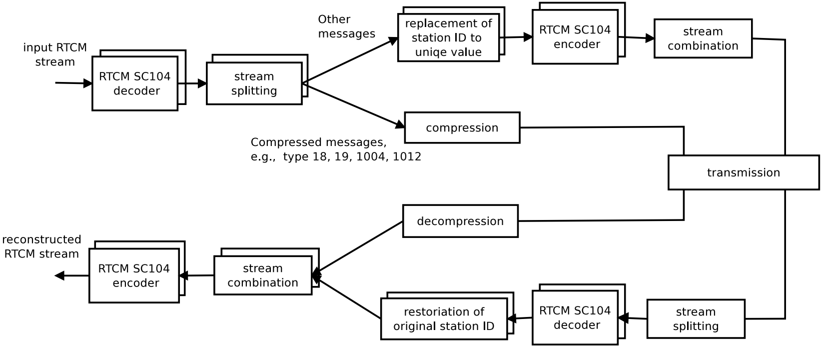

- 200 streams from BKG in Germany inspected
- RTCM 2 - 12%
- RTCM 3 - 88%
- type 18 and 19 - 23.5%
- type 1004 and 1012 - 59.7%
- RTCM 3 format is at least 40% less verbose than RTCM 2, parity bits, "6 of 8" format

# RTCM SC-104 format

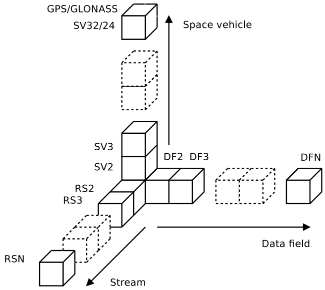


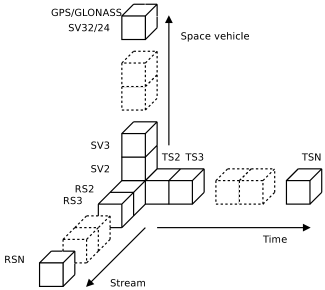

- defined on the presentation layer
- composed from a sequence of data fields
- various data fields encoded with an different number of bits
- every message contains at least information about type and reference station ID
- two main kinds of RTCM messages

# Compression construction



# Data representation




- 3 dimensional representation of data in time stamp and time window
- easy navigation using an index
- data fields compression in a time stamp on the horizontal plane
- compression in time window for different space vehicles
- compression task reduced to a compression of vectors

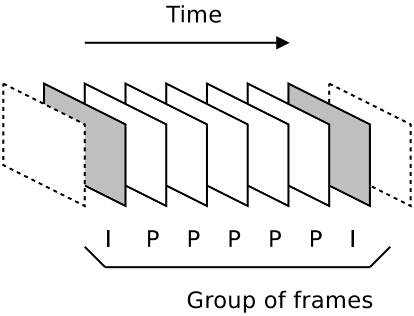
# Compression in a time stamp

- bad performance of dictionary methods
- methods used
  - optimal coding
  - modal value
  - dedicated for data field
- row-by-row or column-by-column
- a profile for every message type

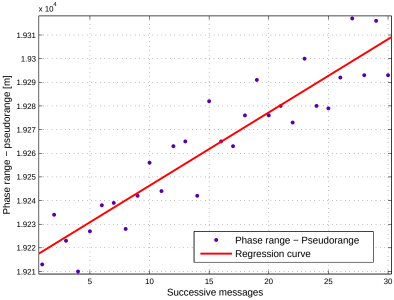
| Message type | 18 | 19 | 1004 | 1012 |
|---|---|---|---|---|
| Space savings | 59.1% | 58.2% | 24.6% | 26.2% |

# Compression in a time window

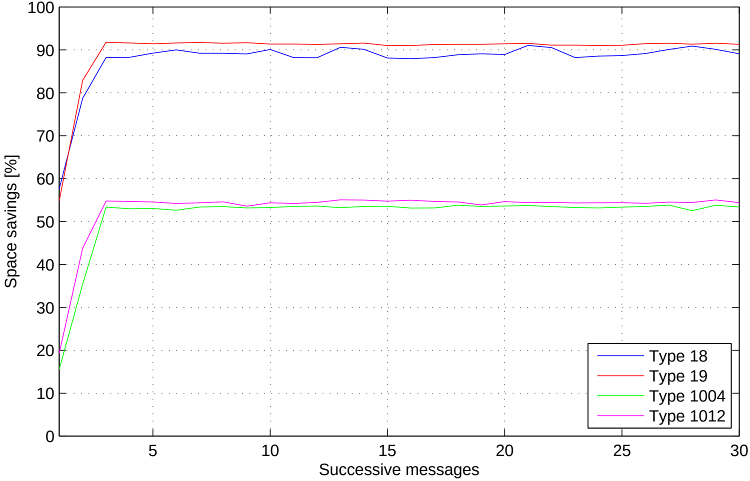
- differential coding used, e.g., in video codecs
- only difference between successive frames is sent
- works in real time
- satellite list update



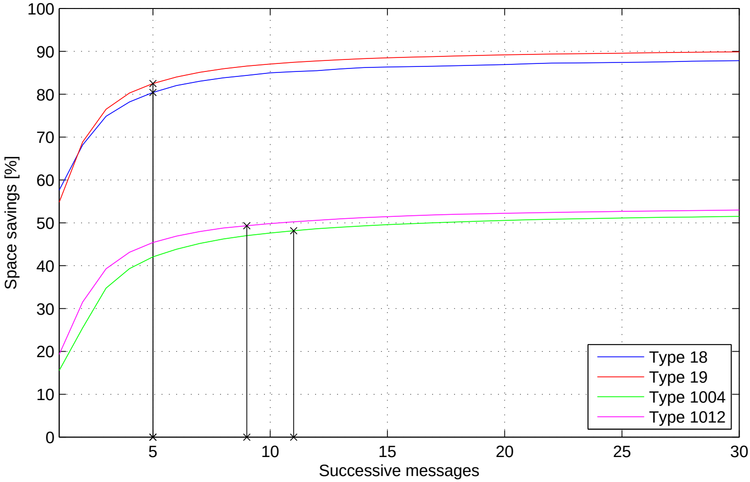

- some values change linearly
- linear predictor
- outlier detection



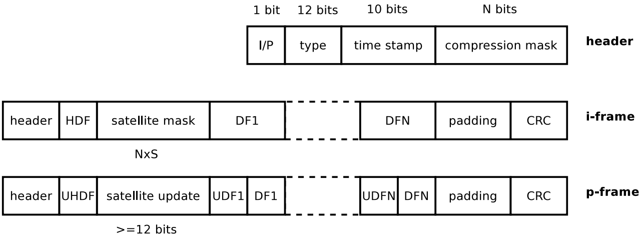
# Space savings of I and P frames



# Space savings within a time window



# Packetizing




- defined on the presentation layer
- other ISO/OSI layers deliver information about:
  - data integrity
  - size
  - lost packets
  - right packet ordering

| no. of streams | I-Frame size B | P-Frame size B |
|---|---|---|
| 1 | 127 | 52 |
| 10 | 1034 | 554 |
| 13 | 1356 | 725 |
| 38 | 3982 | 2141 |
| 100 | 10439 | 5651 |

# Summary and suggestions for future research

- defined compression/decompression construction
- found and implemented compression techniques for most frequently sent messages
- performed offline tests on two data sets

- check if numerical calculations with precise orbital information improve compression ratio
- perform integration and online tests
- perform field tests with satellite

# The End

Thank you for your attention!