

Introduction to BKG Ntrip Client (BNC) Usage

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BNC's technical details

BNC from the programmer's point of view

- BNC source consists currently of approximately 50.000 lines of code
- approximately 90 % is C++, 10 % standard C
- BNC uses a few third-party pieces of software (first of all the RTCM decoders/encoders and a matrix algebra library)
- Qt library is used for
 1. GUI,
 2. networking,
 3. threads,
 4. containers, streams, files, ...

BNC is intended to be

- user-friendly
- cross-platform
- easily modifiable (by students, GNSS beginners)
- useful (at least a little bit ...)

BNC source code

Algorithms used in BNC are intended to be

- correct, but
- as simple as possible

```
//  
////////////////////////////////////  
void bncModel::kalman(const Matrix& AA, const ColumnVector& ll,  
                    const DiagonalMatrix& PP,  
                    SymmetricMatrix& QQ, ColumnVector& dx) {  
  
    Tracer tracer("bncModel::kalman");  
  
    int nObs = AA.Nrows();  
    int nPar = AA.Ncols();  
  
    UpperTriangularMatrix SS = Cholesky(QQ).t();  
  
    Matrix SA = SS*AA.t();  
    Matrix SRF(nObs+nPar, nObs+nPar); SRF = 0;  
    for (int ii = 1; ii <= nObs; ++ii) {  
        SRF(ii,ii) = 1.0 / sqrt(PP(ii,ii));  
    }  
    SRF.SubMatrix (nObs+1, nObs+nPar, 1, nObs) = SA;  
    SRF.SymSubMatrix(nObs+1, nObs+nPar) = SS;  
  
    UpperTriangularMatrix UU;  
    QRZ(SRF, UU);  
  
    SS = UU.SymSubMatrix(nObs+1, nObs+nPar);  
    UpperTriangularMatrix SH_rt = UU.SymSubMatrix(1, nObs);  
    Matrix YY = UU.SubMatrix(1, nObs, nObs+1, nObs+nPar);  
  
    UpperTriangularMatrix SHi = SH_rt.i();  
  
    Matrix KT = SHi * YY;  
    SymmetricMatrix Hi; Hi << SHi * SHi.t();  
  
    dx = KT.t() * ll;  
    QQ << (SS.t() * SS);  
}
```

svn archive

BNC source code may be downloaded from the svn archive using a command

A) `svn co http://software.rtcn-ntrip.org/svn/trunk/BNC`

or

B) `svn co https://software.rtcn-ntrip.org/svn/trunk/BNC`

Option A) is a read-only access. Option B) is for the developers (read-write access). When the source code is downloaded using the `https` (secure protocol) currently two additional sub-directories are retrieved:

- combination
- rinex

The sub-directory “combination” contains the source code of the BNC module that performs the combination of PPP corrections streams provided by several analysis centers (more about the combination algorithms below).

The sub-directory “rinex” contains the module for the post-processing PPP client that uses the RINEX files as input (this directory is not yet made public because it is still under development).

Precise Point Positioning with PPP

BKG Ntrip Client (BNC) Version 2.6

File Help

actions Feed Engine Serial Output Outages Miscellaneous PPP (1) **PPP (2)** Combination Upload (clk) Upload (eph)

Precise Point Positioning (Panel 2)

Antennas ANTEX File LEIT Antenna Name Apply Sat. Ant. Offsets

Sigmas Code Phase Tropo Init Tropo White Noise

Options Use phase obs Estimate tropo Use GLONASS Use Galileo

Options cont'd Sigma XYZ Init Sigma XYZ Noise Quick-Start (sec) Max Sol. Gap (sec)

Options cont'd Sync Corr (sec) Averaging (min)

	Streams: resource loader / mountpoint	decoder	lat	long	nmea	ntrip	bytes
1	products.igs-ip.net:2101/CLK11	RTCM_3,0	50.00	10.00	no	1	121.886 kB
2	products.igs-ip.net:2101/RTCM3EPH	RTCM_3	50.09	8.66	no	1	376.009 kB
3	www.igs-ip.net:2101/FFMJ1	RTCM_3,0	50.09	8.66	no	1	218.731 kB

Log Throughput Latency **PPP Plot**

0.10 m
0.00 m
-0.10 m

Start 08:25:58

08:30 08:31 08:32 08:33 08:34

Add Stream Delete Stream Start Stop Start Post-Processing Help ?=Shift+F1

Precise Point Positioning with PPP (cont.)

BNC provides a good framework for the PPP client (observations, orbits, and corrections stand for disposal).

Main reasons for the PPP module in BNC have been:

- monitoring the quality of incoming data streams (primarily the PPP corrections)
- providing a simple easy-to-use tool for the basic PPP positioning

The PPP facility in BNC is provided in the hope that it will be useful.

- The mathematical model of observations and the adjustment algorithm are implemented in such a way that they are (according to our best knowledge) correct without any shortcomings, however,
- we have preferred simplicity to transcendence, and
- the list of options the BNC users can select is limited.

⇒ Commercial PPP clients may outperform BNC in some aspects.

We believe in a possible good coexistence of the commercial software and open source software.

PPP Options

- single station, SPP or PPP
- real-time or post-processing
- processing of code and phase ionosphere-free combinations, GPS, Glonass, and Galileo

Precise Point Positioning (Panel 1)

Obs Mountpoint X Y Z

Corr Mountpoint dN dE dU

Output NMEA File NMEA Port PPP Plot

Post-Processing Obs Nav Corr

Output

Precise Point Positioning (Panel 2)

Antennas ANTEX File LEIT Antenna Name Apply Sat. Ant. Offsets

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Options Use phase obs Estimate tropo Use GLONASS Use Galileo

Options cont'd Sigma XYZ Init Sigma XYZ Noise Quick-Start (sec) Max Sol. Gap (sec)

Options cont'd Sync Corr (sec) Averaging (min)

Combination of PPP Corrections

User's dilemma:

There are so many different data streams with PPP corrections available on NTRIP caster. Which one should I use?

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Use the combined one!

Are the combined corrections always the best?

It depends ...

The combination of the PPP corrections

- increases the reliability, but
- may (slightly) decrease the quality because the combination algorithm is (currently) not fully correct (the combination algorithms must neglect information that is not provided in correction streams).

Simple combination of PPP corrections

The simple algorithm for the combination

- subtract the analysis-center specific biases
- computes the mean over all corrections for each satellite

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However, for PPP clock accuracy on DD level matters!

Observation equations for two satellites i, j and two epochs t_1, t_2 :

$$L^i(t_1) = \varrho^i(t_1) + c \delta(t_1) - c \delta^i(t_1) + b^i$$

$$L^j(t_1) = \varrho^j(t_1) + c \delta(t_1) - c \delta^j(t_1) + b^j$$

$$L^i(t_2) = \varrho^i(t_2) + c \delta(t_2) - c \delta^i(t_2) + b^i$$

$$L^j(t_2) = \varrho^j(t_2) + c \delta(t_2) - c \delta^j(t_2) + b^j$$

Eliminating the clock parameters $\delta(t_1), \delta(t_2)$ and the ambiguities (biases) b^i, b^j is equivalent to forming a double difference (between two satellites and between two epochs):

$$L^{ij}(t_1) - L^{ij}(t_2) = \varrho^{ij}(t_1) - \varrho^{ij}(t_2) - c \underbrace{[(\delta^i(t_1) - \delta^j(t_1)) - (\delta^i(t_2) - \delta^j(t_2))]}_{\text{DD Clock}}$$

Combination Options

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File Help

INEX Ephemeris Broadcast Corrections Feed Engine Serial Output Outages Miscellaneous PPP (1) PPP (2) **Combination**

Mountpoint	AC Name	Weight
1 CLK11	BKG	1.0
2 CLK21	DLR	1.0

Add Row
Delete

Method Filter

Maximal Residuum 0.2

Combine Broadcast Ephemeris corrections streams.

Streams: resource loader / mountpoint	decoder	lat	long	nmea	ntrip	bytes
1 products.igs-ip.net:2101/CLK11	RTCM_3.0	50.00	10.00	no	1	79.837 kB
2 products.igs-ip.net:2101/CLK21	RTCM_3.0	48.09	11.28	no	1	62.178 kB
3 products.igs-ip.net:2101/RTCM3EPH	RTCM_3	50.09	8.66	no	1	252.925 kB

Log Throughput Latency **PPP Plot**

Precise Point Positioning (Panel 1)

Obs Mountpoint FFMJ1 PPP X 4053455.82 Y 617729.74 Z 4869395.78

Corr Mountpoint INTERNAL dN dE dU

Output NMEA File NMEA Port PPP Plot

Post-Processing Obs Nav Corr

Output

Combination using Kalman filtering

The combination is performed in two steps

1. The satellite clock corrections that refer to different broadcast messages (different IODs) are modified in such a way that they all refer to common broadcast clock value (common IOD is that of the selected “master” analysis center).
2. The corrections are used as pseudo-observations for Kalman filter using the following model (observation equation):

$$c_a^s = c^s + o_a + o_a^s$$

where

c_a^s is the clock correction for satellite s estimated by the analysis center a ,

c^s is the resulting (combined) clock correction for satellite s ,

o_a is the AC-specific offset (common for all satellites), and

o_a^s is the satellite and AC-specific offset.

The three types of unknown parameters c^s , o_a , o_a^s differ in their stochastic properties: the parameters c^s and o_a are considered to be epoch-specific while the satellite and AC-specific offset o_a^s is assumed to be a static parameter.

Combination Results

