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
- \bullet 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& 11.
                      const DiagonalMatrix& PP,
                      SymmetricMatrix& QQ, ColumnVector& dx) {
  Tracer tracer("bncModel::kalman");
  int nObs = AA.Nrows();
  int nPar = AA.Ncols();
 UpperTriangularMatrix SS = Cholesky(00).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 / sart(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.SvmSubMatrix(nObs+1, nObs+nPar);
  UpperTriangularMatrix SH rt = UU.SvmSubMatrix(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():</pre>
  dx = KT.t() * 11;
  QQ << (SS.t() * SS);
```

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svn archive

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

A) svn co http://software.rtcm-ntrip.org/svn/trunk/BNC
or

B) svn co https://software.rtcm-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

				В	KG Ntrij	o Client (B	NC) Versi	on 2.6						- ×	
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Options	•	Estimate t	ropo		Use Galileo										
Options cont'd 0.01 Sigma XYZ Init 100.0 Sigm							YZ Noise 30 Quick-Start (sec) Max Sol. Gap (sec)								
Options cont'd 3 Sync Corr (sec) Averaging (min)															
Streams: resource loader / mountpoint							r la	t	long	nmea	ntrip	bytes]A	
1 produc	cts.igs-ip.	net:2101	/CLK11			RTCM_3	.0 50	.00 1	0.00	no	1	121.886 kB			
2 produc	cts.igs-ip.	net:2101	/RTCM3EPH			RTCM_3	50	.09 8	3.66	no	1	376.009 kB			
3 www.iş	gs-ip.net:	2101/FFI	VIJ1			RTCM_3	.0 50	.09 8	3.66	no	1	218.731 kB		-	
Log Th	roughput	Late	ncy PPP PI	ot											
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-0.10 m	-														
Add Stream	n Delet		Start St	op Start I					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.
- \Rightarrow 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	FFMJ1	РРР	-	x 4	4053455.82) Y	617729.74	Z	4869395.78			
Corr Mountpoint	CLK11			dN		dE		dU				
Output	NMEA Fi	le				NMEA Port		PPP Plot	2			
Post-Processing	Obs			Nav			Corr					
	Output											
Precise Point Positioning (Panel 2)												
Antennas 🛛 ANTEX File LEIAR25.R4 LEIT Antenna Name 🗆 Apply Sat. Ant. Offsets												
Sigmas	5.0	Code	0.02	Phase	0.	Тгор	o Init	1e-6 T	ropo White Noise			
Options	~	Use phase obs		Estimate	e tropo	🗹 Use	GLONASS	🗆 U	lse Galileo			
Options cont'd	0.01	Sigma XYZ Init	100.0	Sigma X	YZ Noise 30	Quic	k-Start (sec)	N	/lax Sol. Gap (sec)			
Options cont'd	3	Sync Corr (sec)		Averagin	g (min)							

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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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 :

$$\begin{array}{lll} L^{i}(t_{1}) & = & \varrho^{i}(t_{1}) + c \; \delta(t_{1}) - c \; \delta^{i}(t_{1}) + b^{i} \\ L^{j}(t_{1}) & = & \varrho^{j}(t_{1}) + c \; \delta(t_{1}) - c \; \delta^{j}(t_{1}) + b^{j} \\ L^{i}(t_{2}) & = & \varrho^{i}(t_{2}) + c \; \delta(t_{2}) - c \; \delta^{i}(t_{2}) + b^{i} \\ L^{j}(t_{2}) & = & \varrho^{j}(t_{2}) + c \; \delta(t_{2}) - c \; \delta^{j}(t_{2}) + b^{j} \end{array}$$

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):

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

Combination Options

				BKG Ntri	p Client (BNC)	Version 2.0	6				-	+ ×
e	<u>H</u> elp											
NE	X Ephemeris	Broadcast Corr	ections F	eed Engine	Serial Output	Outages	Miscellan	eous P	PP (1)	PPP (2) Co	mbination	• •
Ē	Mountpoint	AC Name	Weight									
1	CLK11	BKG 1.0			Add R							
2	2 CLK21 DLR 1.0											
						Delet	te					
					м	ethod		Filter	r	-		
					м	aximal Res	iduum	0.2				
					c	ombine Bro	adcast Eph	emeris co	orrection	s streams.		
-	Streams: res	ource loader / m	ountroint		decoder	lat	long	nmea	ntrip	bytes		
Streams: resource loader / mountpoint 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		
-		o.net:2101/RTCM		RTCM 3	50.09	8.66	no	1	252.925 kB			
					in cin_o	50105	0.00	110		LULINED ND		-
Lo			PPP Plot									
0	0.10 m - NEU	5tart 10:29	:53									
(0.00 m 10:30		10:31		10:32		10:33		~	10:34		-
-1	0.10 m		10.51				10.55			10.54		
				Precise Point	Positioning (Pane	d 1)						
dd	1	ete Stream Sta	rt Stop	Obs Mountpo Sta		РРР	▼		53455.82		617729.74	
dd	1	e te Stream Sta	rt Stop	Sta Corr Mountpo	int INTERNAL		▼	x 40	53455.82	dE	617729.74	d
dd	1	e te Stream Sta	rt Stop :	Sta	INTERNAL NMEA File		· ·		53455.82		617729.74	d PPP F

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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):

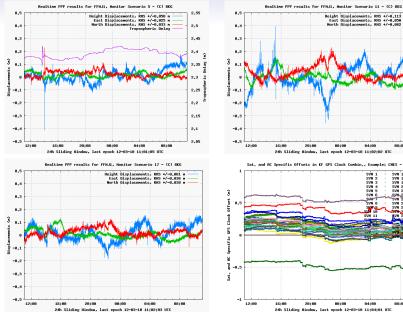
$$c_a^s = c^s + o_a + o_a^s$$

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.

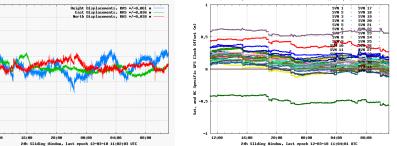
The three types of unknown parameters c^s , o_a , o_a^s differ in their stochastic properties: the parameters c^s and o_a are considered to be epoch-specific while the satellite and AC-specific offset o_a^s is assumed to be a static parameter.

Combination Results





Sat. and AC Specific Offsets in KF GPS Clock Combin., Example: CNES - (C) BKG



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