Current Status of Software Correlators Developed at Kashima Space Research Center

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History of XF-type Software Correlators

- 1960's : Mark-I
  - 144Mbits (720kHz sampling × 200sec) Processing (15-lag correlation) => 90 minutes (IBM360/50) 26.7kbps
- 1980's : CCC* (developed by Kashima Group)
  - 16Mbits (4MHz sampling × 4sec) Processing (64-lag correlation) => 150 minutes (HP1000/A900) 1.8kbps

Soft correlator was developed,
but it took time too much

CCC developer

* CCC : Cross Correlation in a Computer

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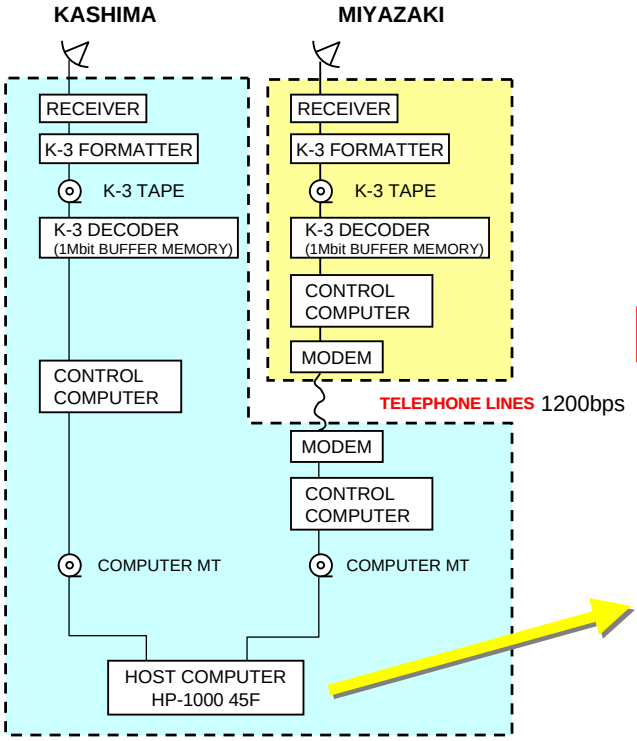
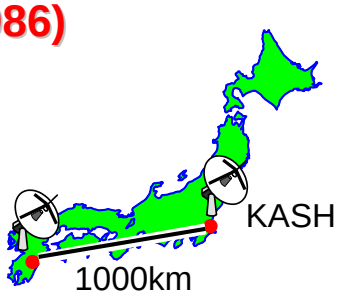
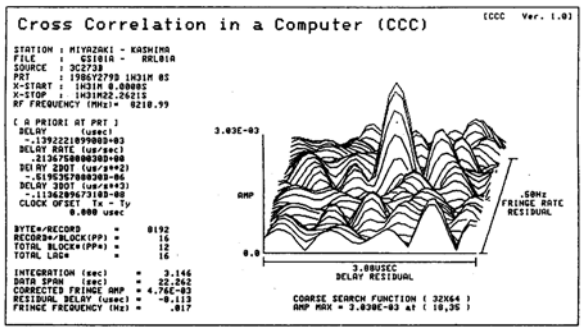
Historical e-VLBI Experiment using Software Correlator in JAPAN (1986)





It took about only 10 hours to get fringes!



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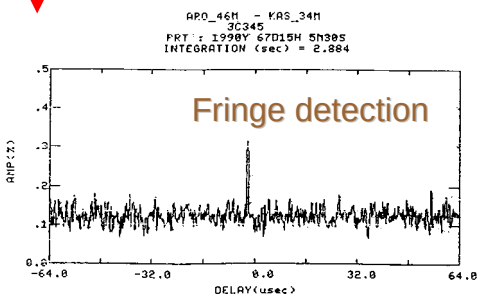
First Canada-Japan WFC VLBI using Software Correlator (1990)

CCC Processing



CCC was used in the first Canada-Japan Wave Front Clock VLBI experiment in 1990

on the ARO 46m Dish

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History of XF-type Software Correlators (continued)

- 2000's : K5 Software Correlator (Kashima) developed by
  - 8Mbits (8MHz sampling ×1sec) Processing (32-lag correlation) => 1 sec (PC Pentium4 2GHz) 8Mbps

K5/VSI Gigabit Software Correlator (FX-type Kashima)

- 100 Msamples => 1sec (PC AthronXP-2500+) 100Mbps

developed by Kimura-san

Note: K5 (16-ch geodetic VLBI system with PC sampler board)
K5/VSI (Gigabit VLBI system with PC-VSI interface)

Requirements for a Software Correlator for Geodetic Use

- Compatible with conventional hardware correlators, such as K3, KSP correlators
  - Consistent definitions in delay, clock parameters, etc.
  - Pcal phase detection
  - Check bit slip or make
  - Processing using a schedule file
- Both K5 and Mark-5 data processing

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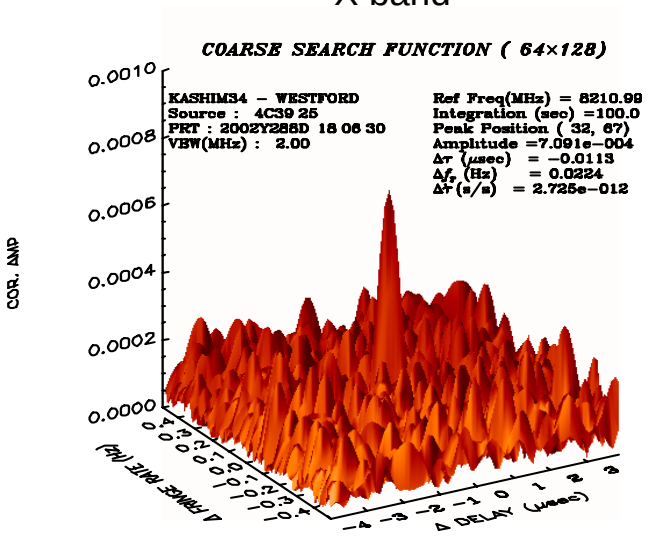
K5−Mark5 Fringes

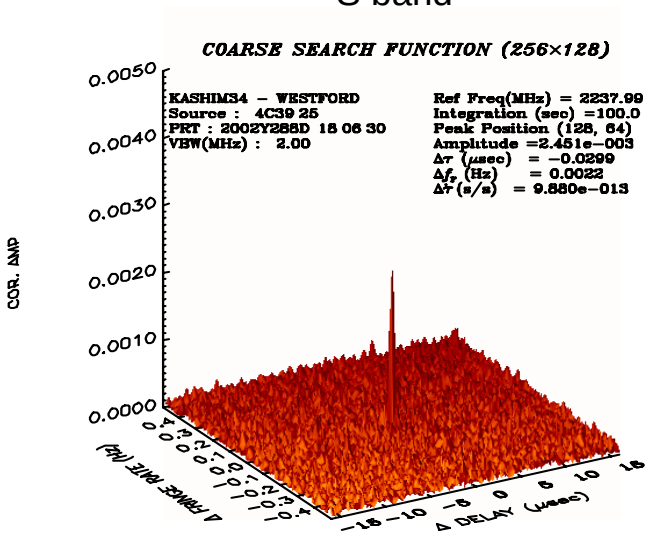
Oct. 15, 2002

Kashima - Westford

X band



S band



4C39.25

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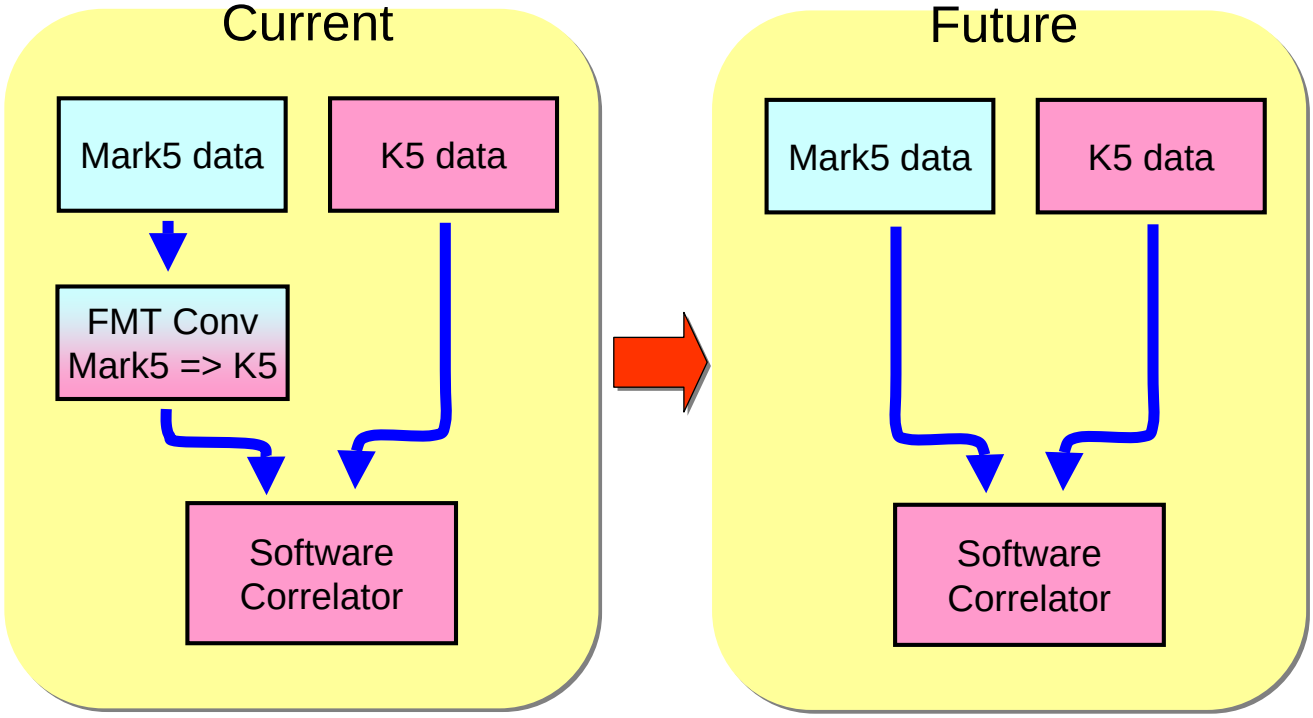
Mixed Raw Data Processing



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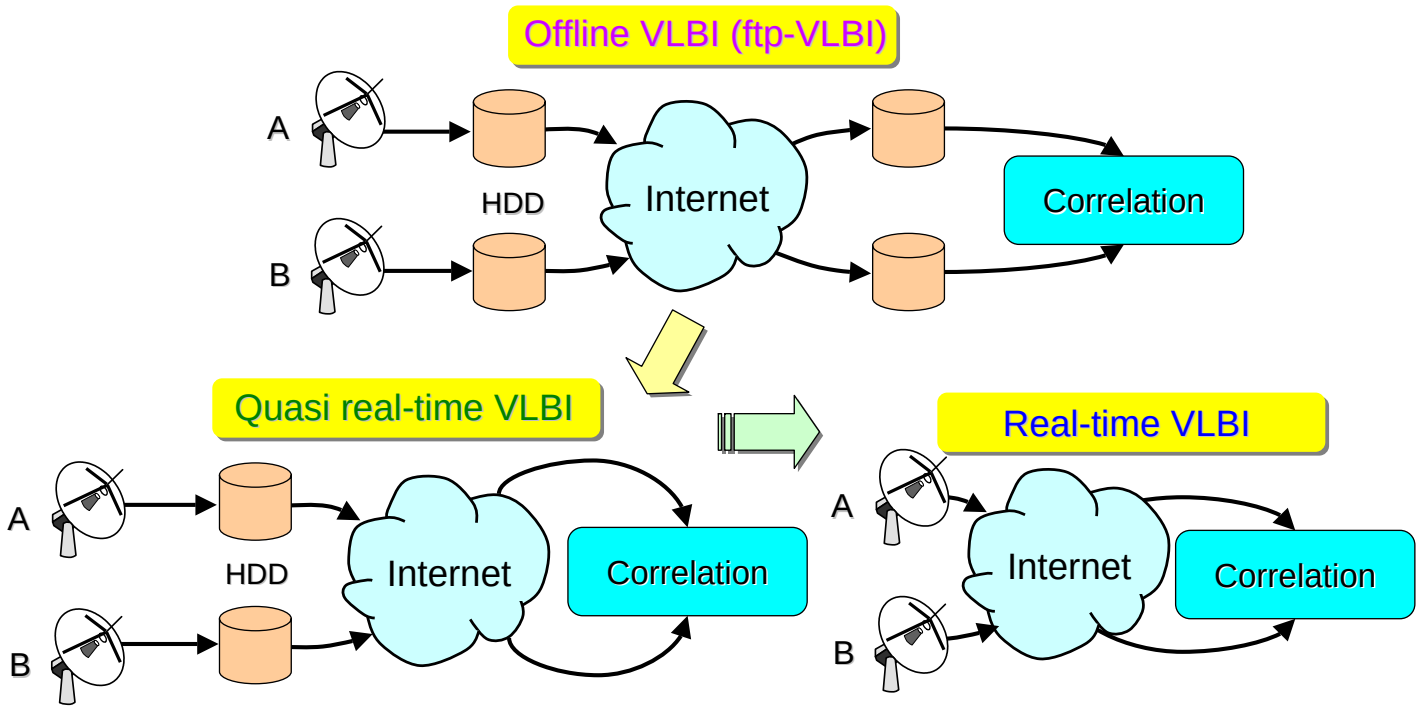
Operation Mode of Internet VLBI (e-VLBI)



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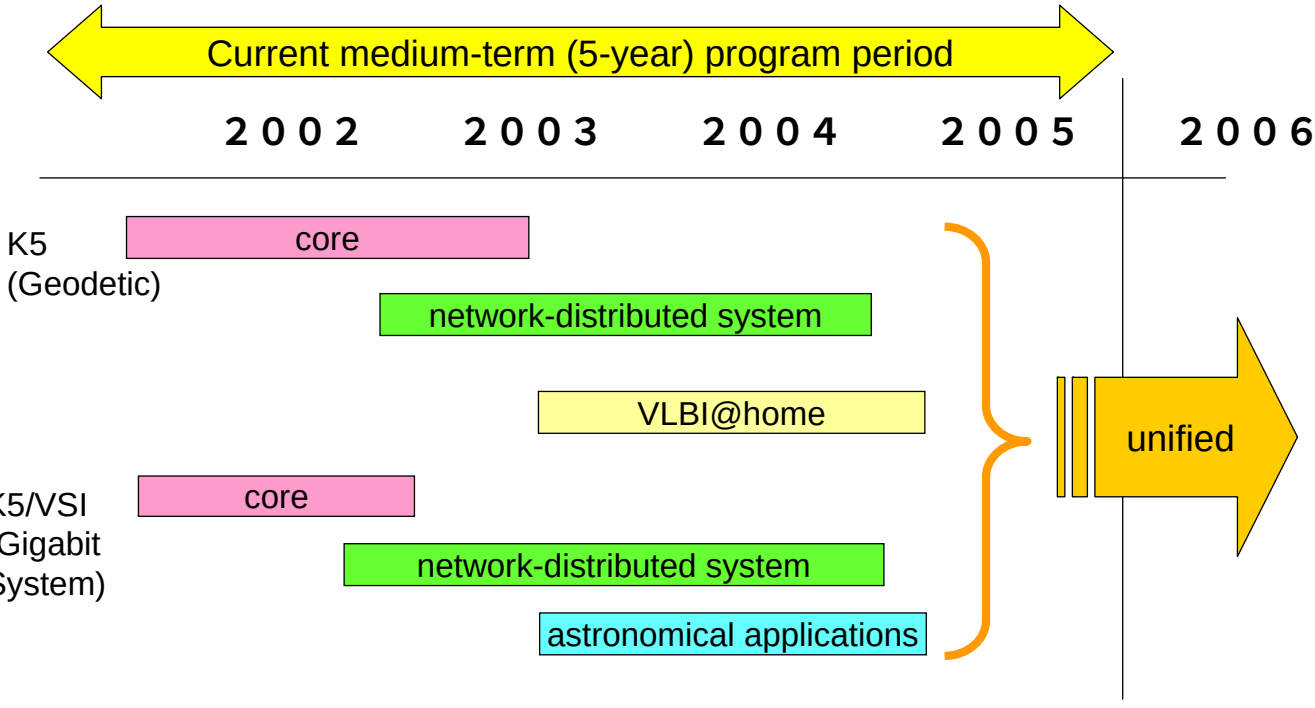
Development Plan of Software Correlators



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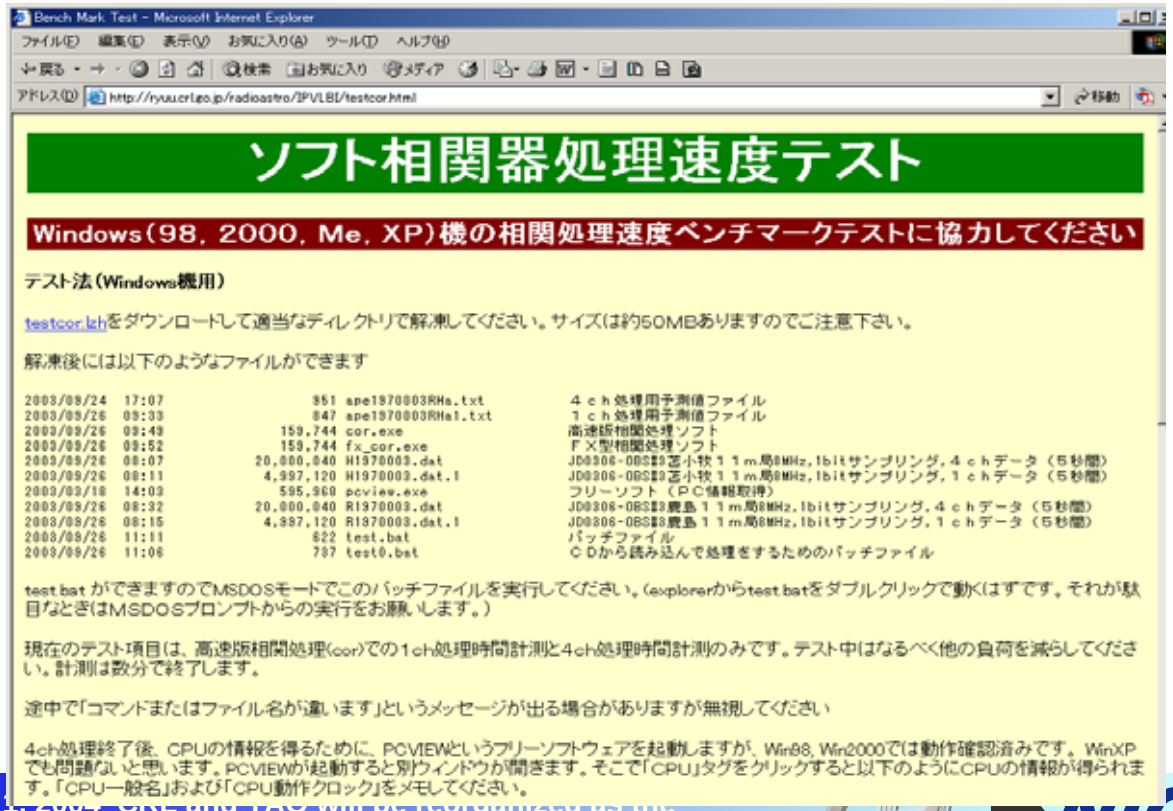
Benchmark Test → VLBI@home



Examples of Benchmark Test Results

処理速度テスト結果(2003/11/11現在)

順位	CPU	クロック周波数(MHz)	OS	1ch処理(秒)	4ch処理(秒)	測定者	備考
1	Intel(R) Xeon(TM)	3065.84	Windows	0.734	2.781	H.T.	
2	AMD AthlonXP-2500+	1833	Windows	0.781	2.782	M.K.	M.K.自宅PC
3	Pentium 4	2539.1	Win XP	0.797	2.953	GSI S.K.	
4	Pentium 4	2386.55	Win XP	0.766	2.969	S.A.	Dell
5	Pentium 4	2539.09	Win XP	0.813	3.047	GSI S.K.	
6	Intel Xeon	2776.41	Win2000 on VMware	0.831	3.064	GSI S.K.	
7	Pentium 4	1993.94	Windows	0.937	3.422	J.N.	
8	Pentium 4	1993.94	Windows	0.938	3.546	GSI K.T.	DELL DIMENSION 8200
9	Pentium 4	2008.89	WinXP	1.000	3.578	GSI S.K.	
10	AMD AthlonXP-2400+	2000.07	WinXP	0.969	3.594	GSI M.I	
11	AMD AthlonMP-2200+	1800	Windows	0.922	3.703	M.K.	
12	Pentium 4	2194.60	Windows	1.109	4.156	J.N.	共用PC
13	Pentium Ⅲ	997.43	Windows	1.250	4.328	R.I	
14	Pentium Ⅲ-M	965.62	WinXP	1.151	4.366	H.O.	ノートPC
15	AMD Opteron-240	1400	Windows	1.188	4.563	M.K.	
16	Pentium Ⅲ	1002.27	Win2000	1.342	4.657	T.K.	SONY VAIO PCV-RX70K
17	Pentium Ⅲ	934.99	Win2000	1.432	4.947	T.K.	日通機初期K5
18	Celeron	1703.86	Win2000	1.312	4.968	T.K.	KaRAS制御PC
19	Pentium Ⅲ	996.77	Windows	1.592	5.588	H.K.	
20	Pentium 4	1495.15	WinXP	1.516	5.703	Y.K.	Compaq Evo D300/SF
21	Pentium Ⅲ-M	844.61	WinXP	1.642	5.708	GSI S.K.	ノートPC(VAIO)
22	Celeron	851.51	Windows	1.732	6.139	R.I	R.I自宅PC
23	Pentium Ⅲ	701.59	Windows	1.802	6.159	H.T.	
24	Pentium 4	1600	Windows	1.641	6.344	M.K.	M.K.自宅PC
25	Pentium Ⅲ	696.41	Win2000	1.903	6.509	GSI M.I	
26	Pentium Ⅲ	551.18	Windows	2.140	7.187	H.O.	
27	AMD Athlon Model 4	1302.3	WinMe	2.030	7.690	Y.K.	Y.K.自宅PC(Compaq Presario)
28	Celeron	500.02	Win98	2.52	8.4	GSI M.I	DynabookSS
29	PowerPC G4	800	Mac	3.32	8.93	R.I	R.I私物(PowerBook G4)
30	Celeron	501.14	Win98	2.690	10.050	J.N.	J.N.自宅PC
31	Celeron	399.92	Win98	3.52	10.71	Y.K.	Toshiba DynaBook SS 3380V
32	PowerPC G4	400	Mac	4.78	13.2	R.I	Power Mac G4

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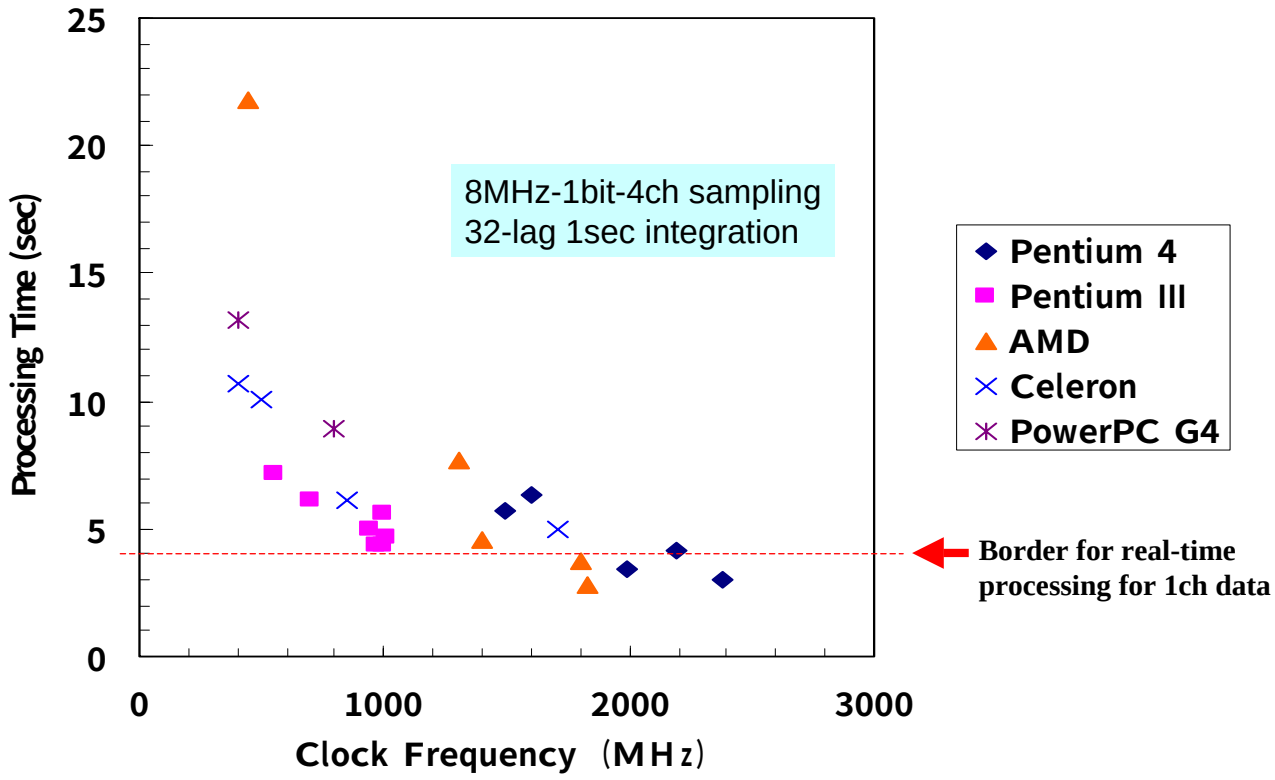
Benchmark Test Results



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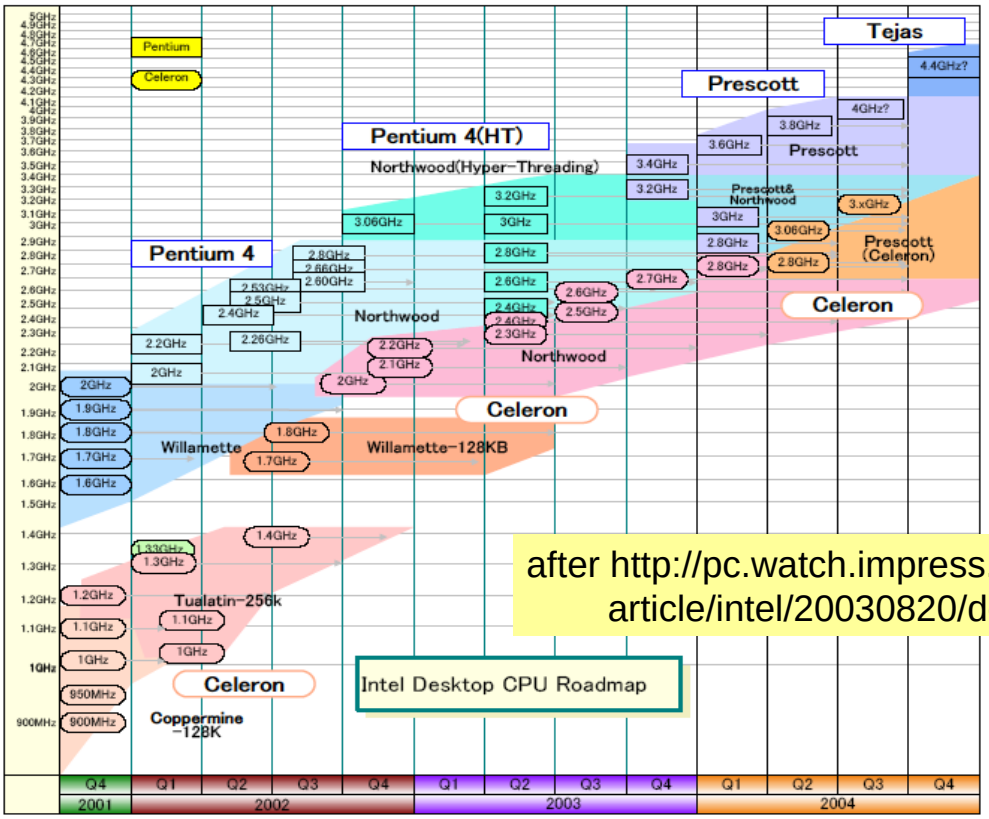
Intel Roadmap



after http://pc.watch.impress.co.jp/docs/article/intel/20030820/desktop.pdf

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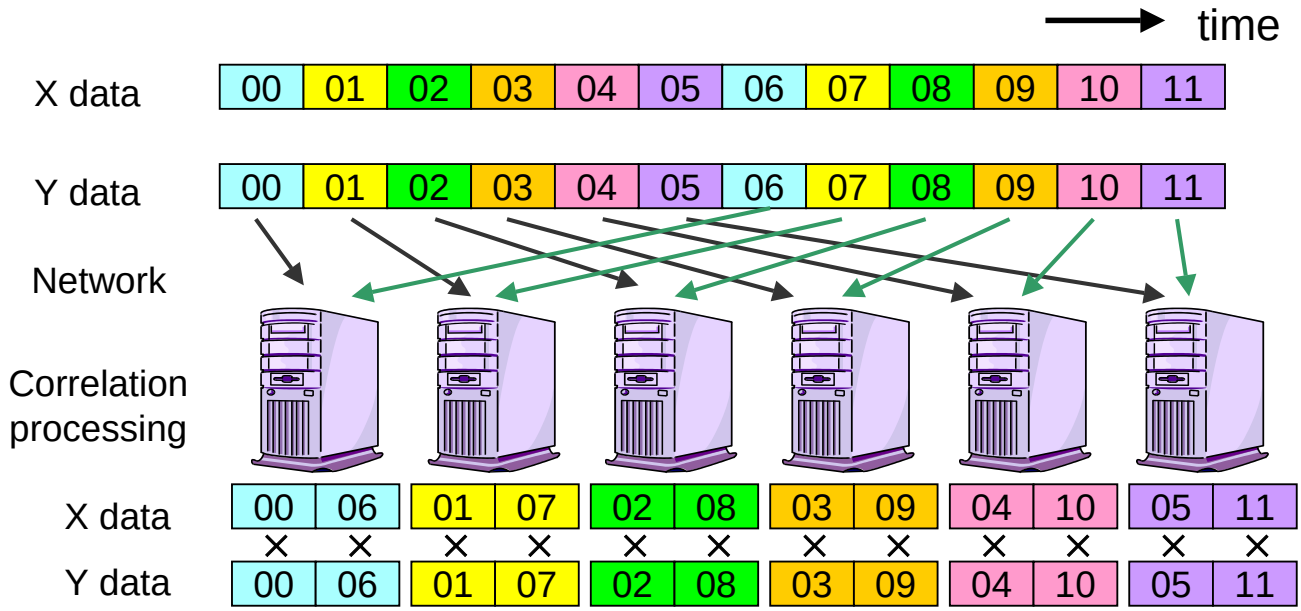
Time-segmented Distributed Correlation Processing



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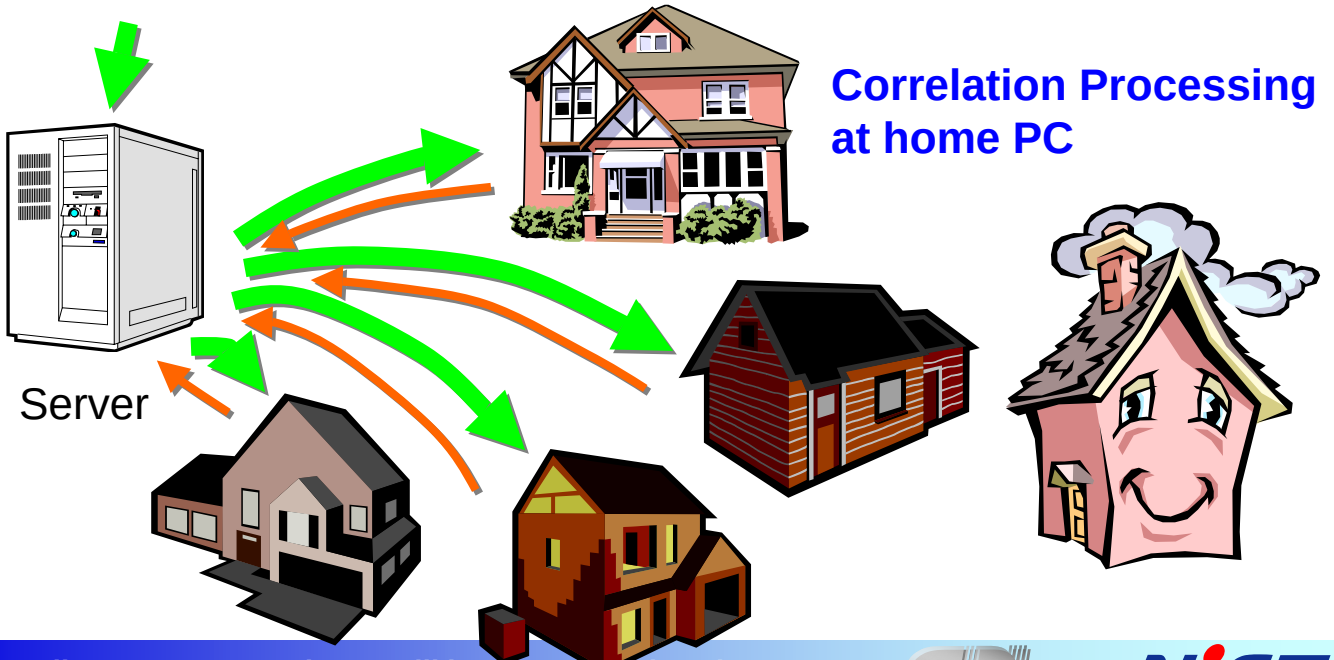
VLBI@home

huge VLBI data



Correlation Processing at home PC

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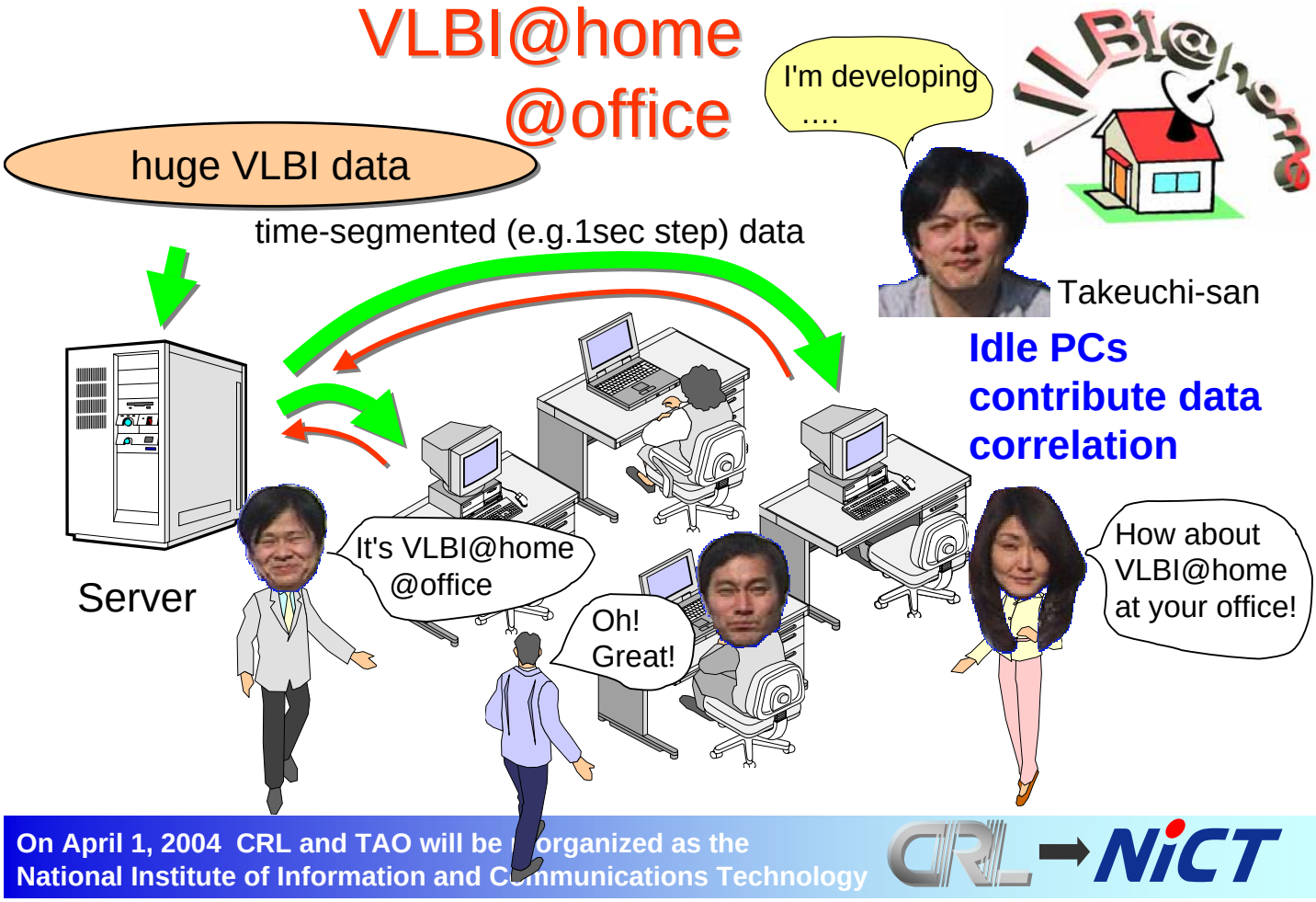
VLBI@home @office



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Summary

- Software Correlator for geodetic use can process 10 Mbps data in real-time at present time.

  Note: Ultra High-Speed Software Correlator developed by Kimura for K5/VSI has a processing speed faster ten or more times (100Msps data in real-time)

Near Future Plans

- Network distributed processing (VLBI@home)
- Real-time Internet VLBI

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