Adaptation in Software Radio using a Complex Organic Distributed Architecture (CODA)

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This document is based on work carried out in the EU sponsored collaborative research project CAST Nonetheless only the authors are responsible for the views expressed here

What we will cover:



<u>Mobile phone Subsystem</u>

Aims of the CAST Project

CODA is a complex organic distributed architecture which was used to deliver intelligent to reconfigure the hardware components of a mobile network transparently.



The aim of the intelligence system was to deliver the best quality of service under a variety of environmental conditions.

CODA in the CAST Project

CODA is made up from five interacting layers

Each layer contains roles tasks and data stores

The model is drawn from cybernetic, cognitive research and knowledge discovery systems.



The CAST project subsystem is made up from three layers of CODA.

In a full CODA implementation this sub-system would interact transparently with every other part of the network to ensure a cohesive and seamless response to the environment

Quality of service involves identifying user trend behaviour over time as well as immediate response to various environmental conditions

An overview of CODA Intelligence

CODA is a five layered architecture. Each layer contains roles, cells, and memory.

Interaction between all components is managed by filters. The feedback loop ensures that the system is able to adapt to the environment intelligently

An overview of CODA Intelligence

This overview shows the sub-system constructed for the CAST project



Component cells in the sub-system co-operate to meet an objective

A CODA Sub-system

The Intelligence Cycle

Intelligence in CODA components depends on the use of memory to adapt



The Demonstration Scenario

The Test Process

Complexity Type	CODA Solution
Complex Data	Tasks are organised by cells initiated by roles and measured by CSFs
Complex Data	Data is Restructured using CODA warehouses according to viewpoint and layer
Complex Interactions	Objectives are undertaken by subsystems and managed via the feedback loop
Overall test	Performance Improved

Producing Test Data

Scen:

A 'real' environment requires the expression of time, group and location variables as a minimum.

Environmental conditions can be normal, threat or opportunity.

Within this environment, variety in the group dimension, expressed as objects of interest, occurs in the users and calls.

irio fe	or 30/01/2003									
	Count of event	servicetype 💌								
	event 🗸 🗸	fax	jpeg	mp3	sms	video	voice	wap	www	Grand Total
	start	798	805	600	5078	603	5399	659	801	14743
	Grand Total	798	805	600	5078	603	5399	659	801	14743

Calls originate from various users with different types of mobile devices, contracts and service requests. Users are at 10 possible BSC locations. Calls occur over a timeband on a day-type, (the test environment only considers one non-holiday weekday).



CODA Cells are based on organic systems. They are pre-set with operational parameters known as critical success factors and operate semi-autonomously unless they cannot meet operating tolerances.

This is an implementation of a CODA Cell in the CAST scenario

Monitoring Ops Layer - Base Stat BS: [1001 canterbuy Lines: 10 Type: provincial Free: 7 Date: 16/09/2002 Danger 3 Timeband: 0300-1200 BS Status: Vellows: 0 Pause Auto Status: 0 Pause Auto Status: 0 Next Manual Recfig? Event Clock Mode: Errors:	on Call Processing with Preset Data - Red sce Previous Event Results Blocks: 30 Free: 24 Danger: 6 Janger: 6 Service Type: voice Divett: 2 Max 10 reepting Caller Tet: 0 Device Type: Voice User Type: Inne 09:01:34 End Time: 10 Manual Bandwidth: 0 Line No	Error Report Err Status: n Err Status: n Err Type: 0 Err Severity: 0 Usr Err Msg: No error message sent to user Critical Success Factor CSF Level: 7 N n 9 n	Initiator: 07896554356 Service Type: User type: Device type: Make/Modet: Event type: end					
Bit Profile Pax WWW JPEG Video MP3 Bit Profile Profile Profile Profile Profile Bit Profile Profile								

The BSC cell filters and critical success factors can be viewed and adjusted by an operator as the system manages calls. Otherwise adjustment is fully automated

Failure CODES

The special filter settings are Adjusted by the CODA intelligence cells

Depending on the types of failures cells are reporting.

An example of the call failure types is shown here

The failure details are stored in the operating log of the cell which failed and sent to the intelligence layers

	Failure type
code	Code description
0	Call ok
1	1 divert used
2	2 diverts used
3	Receiver busy
4	Receiver cannot take
5	Mobile device failure (caller)
6	Mobile device failure (receiver)
7	Receiver BSC rejects non-contract call (BSC yellow/red)
8	Start BSC rejects non contract call (BSC yellow/red)
9	Start BSC filters out a non contract call
10	MSC filters out non contract call (not in demonstrator)
11	Receiver BSC fails to divert contract call
12	Caller BSC can't divert a contract call
13	Caller BSC filters out a contract call

service request	User cell details						
service type	user filters	user online status logs	user logs				
	ok	ok	yes				
	ok	ok	yes				
	ok	ok	yes				
	ok	busy/offline	yes				
	receiver filter	0	yes				
	ok	ok	yes				
	ok	ok	yes				
	ok	ok	yes				
	ok	ok	yes				
	ok	ok	yes				
	ok	ok	yes				

BSC cell details								
	BSC							
	status							
	{Red							
	Green							
BSC filters	Yellow}	BSC logs						
ok	G	yes						
ok	R/Y	yes						
ok	R/Y	yes						
ok	0	0						
ok	G	yes						
ok	Y/R	yes						
ok	Y/R	yes						
ok	any	yes						
not	Y/R	yes						
not	Y/R	yes						
ok	Y/R	yes						

Calls may fail
in any one of
the three
interacting
operational
cells:
MS,BSC,MSC

	MS	Cell failure code		
		MSC		
		status		
		{Red		
		Green		
	MSC filters	Yellow}	MSC logs	Failure codes
	ok	G	yes	0
	ok	G	yes	1
	ok	G	yes	2
	ok	0	yes	3
	ok	G	yes	4
7	ok	G	yes	7
_	ok	G	yes	8
	0	0	yes	9
	ok	G	yes	11
	ok	G	yes	12
	0	G	yes	13

Testing a Complex System

Proof of Intelligence

The sub-system adapts to the variety in this environment. As calls are executed, the sub-system attempts to adapt to and modify the environment by either restricting or encouraging usage to make effective use of the lines and bandwidth available by means of special filters.

city	downtown	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
westend	downtown	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
ealing	down town	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
finchley	suburban	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
barking	suburban	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
maidenhead	provincial	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
aylesbury	provincial	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
luton	provincial	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
chelmsford	provincial	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn
tilbury	provincial	crisis	weekday	30/01/2003	1500-1800	6	ууу	yyn	nnn	nnn	nnn	nnn	nnn	nnn

Testing a Complex System

Proof of Intelligence

Complexity Type	As Demonstrated in Scenario
Complex Data	Must identify learn & adapt filters to balance network usage
Complex Data	Call data, user data, performance data, is hierarchical & changes by time & by perspective
Complex Interactions	Impossibility of correctly predicting hardware failure or environmental conditions & possibility of seeing new trends

The Application Programs

The intelligence cycle was demonstrated in three demonstrator programs

CODA Red

This shows response to 'threat' environmental conditions

CODA Blue

This shows response to the different types of system usage

Coda Green

This shows intelligent adaptation

CODA Red

Objective	Critical Success Factors							
Coda Definitions	Identify pattern from: Range of measurable environmental conditions	Select from range of possible operating conditions	Apply run time variable from range of possible measurable operating values					
Coda Red Example (identify) maintain minimum service under failure conditions	Detect threat dimensions	Threat = three base stations orange or one base station red	Adjust Contract filters Special filters Device filters					

Each program is pre-set with slightly different objectives in order to show different aspects of the intelligence cycle

CODA Red shows how the systems BSC cells automatically divert calls when the system is busy

Monitoring Operations L	.ayer - Base Sta	ition Call Pro	cessing with Pres	set Data					
Base Station Details BS: [1007] BS: [1007] Ippe: provincial Date: 16/09/2002 Timeband: [0900-1200] Control Panel Partee Auto Switch Mode Next Manual Event Clock 10:22:13 Slower Slower BS Call Log 144 0789655 (10:14:30) 146 0789655 (10:16:06) 144 0789655 (10:16:06) 146 0789655 (10:16:06) 149 0789655 (10:16:06) 146 0789655 (10:16:06) 149 0789655 (10:16:06) 147 0789655 (10:16:06) 149 0789655 (10:16:06) 146 0789655 (10:16:06) 149 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 145 0789655 (10:16:06) 140 0789655 (10:16:06) 150 0789655 (10:20:06) 150 07896	Lines: 10 Bk Free: 5 Fr Danger 6 Da BS Status: Din Yellows: 8 Ms Status: Online diverting Rectig? n Mode: Ma Errors: 90 	ocks: 30 ee: 18 anger: 15 vert: 2 ax: 10 O 10 O 10 O 2 anual 008 O 2 Image: 10 O 2 Image: 10 Image: 10	Previous Event Re Caller id No:	Exaults 142 142 554350 1999 gold laptop 10.13.33 10.21:54 501 3 10.21:54 501 13 14 1 10.789652 501 0789652 137 0789652 137 0789652 138 078965 138 078 078 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Error Report Err Status: In Err Status: In Err No: In Err No: In Err Severity: In Err Severity: In Err Geverity: In Err Gever	BS Line C Line C	eu sade Jaine Calid y 153 y 154 y 155 y 156 n	Incoming Even	nt Clos O7896554351 O7896554351 end Station Filter fig: cstValue makeModel ~ D Dell Inspiror O NEC 3000L O NEC 30
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Each BSC cell has three possible operating conditions: red, yellow and green

The MSC decides which base station to divert calls to and keeps track of the overall system traffic

SC De	etails																
SC ID:	1	Tim	e Band:	0900-1	200	Tot Line C	apacity:	100)	Reco	nfig Stat	us: 0		-			-
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	16/09/2002		10:59:03 0	900-1200		auth		UMTS	1	JMTS		UMTS		silver			153
	16/09/2002		09:00:00 0	900-1200		auth		cambridge	0	ambridge				silver			15
	16/09/2002		09:00:00 0	900-1200		auth		canterbury	0	anterbury				silver	-		15-
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Adjustments to special filters are managed by the MSC using CODA advice

CODA Red shows how CODA manages if a base station 'fails'

View UIR View Device				Name Contr My Te Online Call te	e: al act: si el: 0 e: c D: 1: ce Mes	oe Iver 78965 23456	554322 UMTS 57890	-Serv sms voice wap fax mp3 www jpeg video	rice Men			Jans									
	OM 15 Scenario							Jugo													
The GSM Base stations in the user's vicinity are close to failure. When the user attempts to send a call (providing if his contract is gold or silver and his device has UMTS capability) the failing BSC requests MSC to log user onto the UMTS BSC Discontinue UMTS scenario?				r's call silver y) g	- Mob c=con d=dev sp=sp filter al overric contra filter	Dev Filte tract sm ice voi ecial wa ecial fax ways mp jes wv ct jpe vid	rs C s M p M 3 I g I leo I	d sp N N N N N N N N N N N N N N N N N N N	Service new filt Devic Mode BSC Tban	e chains (r ers (see M ce: [a el: [: [nd: [ot shown SC screet aptop Dell Ins IMTS 900-1:	piror	with X	S sp mi sy it l TH us	oecial filt ecial filt eximisin stem ar has key HREATS ers.	Filter or has g OPP nd its u role of 3 to sy	key role ORTUN Isers. ¹ minimis stem an	in ITIES ing dits	for		
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Only one rule is triggered in CAST – this is that silver users with device capability are reconfigured for UMTS services

This slide shows the MSC adjustment to user profiles in the event of a base station failure

	ODA Laye	er 1 -	Operatio	ins - MSC	C Role – User A	uthen	tication	Process									2
M	SC De	tails -															
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	16/09/2 16	2002 030 2002 030 2002 030 2002 030 2002 030 Filters Type M. t De Sc Sc Sc Sc Sc De Er Entific	00-1200 o 00-1200 v 00-1200 c 00-1200 c 00-1200 c 1 akeModel ell Inspiron 5 ony Vaio 15 ony Vaio 20 ikson 123 cation F UTC	xford st ictoria ambridge anterbury Make/mod sms 250(y 200(y 200 200	459 down t 325 down t 230 provinc 399 provinc 65M UTR voice 3456 0 y 3456 0 y 3456 0 y 3456 0 y 4567 4987 y 1234 0 y User device type Tetho	own jal jal softwa 3SM1L 4567 4567 3456 1234 3456 1234 3456	10 10 10 10 10 10 10 10 10 2345 9 0 2345 9 0 2345 9 0 9 2345 9 0 9 0 9 2345 9 0 9 2345 9 0 9 2345 9 0 9 2345 9 0 9 2 345 9 10 10 10 10 10 10 10 10 10 10 10 10 10	10 10 55M2[UTf 3456 4567 49 3456 1234 31 2345 are unknown serName	30 30 30 30 30 30 32 fax 35N 0 y 34 87 y 34 87 y 34 90 y 37 40 y 49 0 y 23 to the MSC u AuthCode	30 30 30 28 28 28 28 56 0 y 56 1234 y 45 0 y 87 3456 y 45 0 y 10 user attemp	7 7 7 3 3 3 456 4567 4 567 4 2 3 4567 4 567 4 2 3 4567 4 567 4 567 4 567 4 567 4 567 4 567 4 567 4 567 56 56 56 56 56 56 56 56 56 56 56 56 56	23 23 23 23 23 23 937 y 1140 y 0 y 1987 y 0 y 1987 y 0 y 10 y	y y y y sM5[UTR5] s456 0 567 4987 3456 0 234 3140 5567 0 5567 0	y y y y y 45 y 45 y 34 y 34 y 32	green green green green 567 0 y 567 2345 y 456 0 y 456 0 n 456 0 n	y y y y y y y y y y y y y y y y y y y	
	16/09/2 16	2002 090 2002 090 2002 090 2002 090 2002 090 Filters Type M. t De Sco Sco En tific Pe	00-1200 o 00-1200 v 00-1200 c 00-1200 c 00-1200 c 1 akeModel ell Inspiron 2 ell Inspiron 5 ony Vaio 120 ikson 123 cation F UTC	xford st ambridge anterbury Make/mod sms y50(1y) 000 y 00 y 00 y 00 y 00 y 10 qd24c	459 down 1 325 down 1 230 provinc 399 provinc 101 provinc 102 pro	own jal jal softwa <u>3SM1 </u> 4567 4567 3456 1234 3456 1234 3456 1234 9 8 9 9 9 9 9 1234 3456 1234 1	10 10 10 10 10 10 10 10 2345 y 0 y 2345 y 0 y 2345 y 0 y 4987 y 0 y 4987 y 0 y 4987 y 0 y	within mobile 35M2/UTR 3456 4567 49 3456 1234 31 2345 are unknown serName be	30 30 30 30 30 30 32 fax 35k 0 y 34 87 y 34 0 y 37 40 y 37 40 y 37 40 y 23 to the MSC ut AuthCode okabeok	30 30 30 28 28 56 0 y 56 1234 y 45 0 y 87 3456 y 45 0 y 87 3456 y 45 0 y 10 user attem DeviceType	7 7 7 3 3456 1 23456 1 23456 4567 4 2345 3456 4567 4 2345 sts to auther Mak BS Dell UM	23 23 23 23 23 23 23 23 23 23 23 23 23 2	y y y 3456 0 567 4987 3456 0 234 3140 567 0 0 nlin sms s y y	y y y y y y 45 y 45 y 34 y 34 y 34 y 34	green green green green 567 0 y 567 2345 y 456 0 y 308 4987 y 456 0 n	y y y y y y y y y y y y y y y y y y y	
	16/09/2 16/09/2 16/09/2 16/09/2 16/09/2 evice I bandset bandset laptop palmtop ser Ide UserTyp silver	2002 090 2002 090 2002 090 2002 090 2002 090 Filters Type M. t De Sco Sco En Entific pe	00-1200 o 00-1200 v 00-1200 c 00-1200 c	xford st ictoria ambridge mbridge xmbri	459 down 1 325 down 1 230 provinc 399 provinc 65M UTR voice 3456 0 y 2345 2976 y 3456 0 y 4567 4987 y 1234 0 y User device type TelNo 0789554305 0789554305	own iial iial o softwa 3SM1L 4567 4567 3456 1234 3456 1234 3456 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 56 234 234 234 234 234 234 234 234 234 234	10 10 10 10 3re routines JTR1 wap 0 y 2345 y 0 y 4367 y 0 y 0 y ke/ model ord U a a	100 100 100 100 100 100 100 100 100 100	30 30 30 30 30 30 32 fax 35h 0 y 34 87 y 34 87 y 34 0 y 37 0 y 23 to the MSC ut AuthCode okabeok okabeok	30 30 30 28 28 28 28 28 28 28 28 28 28 28 28 28	7 7 7 3 3456 1 2345 3 3456 4 4567 4 2345 ts to auther ts to auther Mak BS Dell Uh Dell Ca	23 23 23 23 23 23 937 y 140 y 0y 3 1987 y 0y 4 1987 y 0y 4 iticate utrar Actis 11 y y 11 y y	y y y y y y y y y y y y y y y y y y y	y y y y y 45 y 45 y 34 y 34 y 34 y 34 y 34 y 34 y 34 y 34	green green green green 3M6 UTR6 vide 567 0 y 567 2345 y 456 0 y 456 0 n 2 mp3 fax ipe n y n	y y y y y 35SM7/UTR 1937 3456 123 3745 4987 345 0	
	16/09/2 16/09/2 16/09/2 16/09/2 16/09/2 16/09/2 evice I bandset bandset bandset laptop laptop laptop laptop ser Ide UserTyp silver gold bronze	2002 050 2002 090 2002 090 2002 090 2002 090 Filters Type M. t De Sco Sco Entific pe	00-1200 o 00-1200 v 00-1200 c 00-1200 c 1 akeModel Ell Inspiron 2 Ell Inspiron 2 Ell Inspiron 2 Inspiron 2 Ell Inspiron 2 Sation F UTC	xford st ictoria ambridge anterbury Make/mod sms 5501 y 5501 y 5501 y 5001 y 00 y y 20 y 20 y 20 y 20 y 20 y 20 y	459 down t 325 down t 230 provinc 399 provinc 19 specific pointers t 65M UTR voice 19 specific pointers t 65M UTR voice 12 345 0 y 2345 2976 y 2345 0 y 1234 0 y 1334 0 y 133	own iial iial o softwa 3SM1L 4567 4567 3456 1234 3456 1234 3456 1234 and mai Passw eba demha neelia	10 10 10 10 3re routines JTR1 wap 0 y 2345 y 0 y 2345 y 0 y 0 y 4987 y 0 y 0 y 4987 y 0 y 2345 u 10 y 4987 y 0 y 2345 u 10 y 2345 u 10 y 2345 y 0 y 2345 u 10 u 10 u 10 u 10 u 10 u 10 u 10 u 10	100 100 100 100 100 100 100 100 100 100	30 30 30 30 30 30 30 30 30 30 30 30 9 21 82 fax 32 fax 32 fax 30 9 9 9 9 9 9 9 9 9 9 23 0 9 2 37 0 9 9 2 37 0 9 9 2 37 0 9 9 2 38 0 9 9 30 30 30 30 30 30 30 30 30 30 30 30 30	30 30 30 28 28 43 43 43 45 0 45 15 15 15 15 15 15 15 15 15 1	7 7 7 3 3SM4[U 3456 1 2345 3 3456 4 4567 4 2345 3 3456 4 2345 3 3456 1 2345 3 3456 1 2345 3 3456 1 2345 3 2345 1 2345 1 2	23 23 23 23 23 23 23 23 23 23 23 23 23 2	y y y y y y y y y y y y y y y y y y y	y y y y y y 45 y 45 y 34 y 53 y y 32 y y 32 y y y y y y y y y y y y	green green green green 567 0 y 567 2345 y 456 0 y 308 4987 y 456 0 n 2 mp3 fax ipe n y n n n y n	y y y y y 3456 123 3745 4387 345 0	
	is/09/2 is/09/2 is/09/2 is/09/2 is/09/2 evice i bandset isptop laptop laptop paimtop ser ide UserTyp silver gold bronze bronze	2002 090 2002 090 2000 090 50 50 50 50 50 50 50 50 50 50 50 50 50	00-1200 o 00-1200 v 00-1200 c 00-1200 c	xford st ictoria ambridge anterbury Xake/mod sms t500 y 000 y 00 0 0 0	459 down 1 325 down 1 230 provinc 399 provinc 399 provinc 101 Provinc 3456 0 y 2345 2376 y 2345 0 y 2355 0 y 235 0 y 23	own ial ial o softwa 3SM1 4567 3456 1234 3456 1234 3456 1234 and mal Passa demha neelia ila	10 10 10 10 3re routines JTR1 wap 0 y 2345 y 0 y 2345 y 0 y 4987 y 0 y ke/ model ia a a a a a a a a a	100 100 100 100 100 100 100 100	30 30 30 30 30 30 30 30 30 30	330 30 28 28 28 28 28 28 43 28 28 43 28 28 43 28 43 28 43 28 28 43 28 28 43 28 28 43 28 28 43 28 28 28 43 28 28 28 28 28 28 28 28 28 28 28 28 28	7 7 7 7 3 3456 1 23455 3456 4567 4567 4567 4567 4567 4567 4567 4	233 233 233 233 233 237 237 237 237 237	y y y y y y y y y y z z z z z z z z z z	y y y y y y y y y y y y y y y y y y y	green green green green 567 0 y 567 2345 y 456 0 y 456 0 n 2 m3 fax ipe n y n n y y n n n n n n n	y y y y 133M7 UTR 1337 3456 123 3745 43987 345 0	
	16/09/2 16/	2002 090 2002 090 2002 090 2002 090 2002 090 Filters Type M. t De De Sco Sco Entific pe	00-1200 o 00-1200 v 00-1200 c 00-1200 c	Aford st ictoria ambridge anterbury Make/mod sms 250(y 250(y 2000 y y 000 y y 2000 y y 2000 y 1 gold2te 0 standard 0 standard	459 down 1 325 down 1 230 provinc 399 provinc 65M UTR vaice 3456 0 y 2345 2976 y 3456 0 y 1234 0 y	own iial iial asoftwa	10 10 10 10 10 3re routines JTR1 wap 0 y 2345 y 0 y 4987 y 0 y 4987 y 0 y 4987 y 0 y 4987 a 10 4987 a 10 4987 a 10 4987 a 10 4987 a 10 4987 a 10 10 10 10 10 10 10 10 10 10 10 10 10	100 100 100 100 100 100 100 100	30 30 30 30 30 30 30 30 30 30 30 30 30 3	30 30 328 28 289 28 280 28 300 28 301 28 302 28 303 28 304 28 305 28 306 1234 y 45 0 y 87 3456 y 45 0 y 161 user attem DeviceType laptop handset laptop	7 7 7 7 3 35M4[U] 3456 1 23456 1 23456 1 23456 4 4567 4 23455 1 4567 4 2345 1 0 cell uher 0 cell ce	23 23 23 23 23 23 37 23 37 23 140 y 0 y 1987 y 01y * 01y * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 * 1010 *	y y y y y y y y y y z z z z z z z z z z	y y y y y y y y y y y y y y y y y y y	green green green green 567 0 y 567 2	y y y y y y y y y y y y y y y y y y y	

This shows another possible scenario of network saturation



The same rule has been triggered

CODA Blue

Objective	Critical Success Factors							
Coda Definitions	Identify pattern from: Range of measurable environmental conditions	Select from range of possible operating conditions	Apply run time variable from range of possible measurable operating values					
Coda Blue Example (learn) maintain balanced usage of lines and bandwidth	Threat opportunity normal	BSC status MSC status MS status	Contract filters Special filters Device filters					

CODA Blue shows adjustment to special filters over time



There are two types of feedback:

The feedback loop under threat, when emergency special filters are imposed, The opportunity feedback, when special offer filters are imposed

CODA Blue shows the normal feedback based on analysis of call patterns



Most adjustments are made in the initial authentication process

The user authenticates when he logs on to any compatible device



Only one device may be logged in by the same user at any given time

The system returns any special permissions, special offers, reductions, advice etc at the log in and at the beginning of a timeband



An example of a special offer made within a timeband



CODA Green

Objective	Critical Success Facto	uccess Factors					
Coda Definitions	Identify pattern from: Range of measurable environmental conditions	Select from range of possible operating conditions	Apply run time variable from range of possible measurable operating values				
Coda Green example (Adapt) modify behaviour according to trend	Detect clusters over time	Depending on Time Group location and forecast details	Adjust Contract filters Special filters Device filters				

CODA green is designed to analyse trends to to adapt responses automatically

In order to do this ten active base stations were built each managing calls independently,

a (ODA Layer 2 - M	obile Device Call	Generator										
гТ	imeband Sc	enario Contr	ols	- rDev	ice Filter-							-	
Ca	Il duration max (10 - 1	20 secs)	Law and		Dell Dell Si	ony Sony	Erikson Eri	kson Sams	Sams Bosc	h Bosch	NEC	NEC	
	4		102 sec	s	Inspiron Inspiron V 2500 5000 15	aio Vaio 500 2000	123 17	5 230	231 128	64	1000×	3000L	Oda Colutions
As.				sms		U	U U	v	U U	n	v	v	9
	sms voice wap	p fax mp3	www ipeg video	voice									
				wap				,					
				fax	y y y	, y	y y	,	y y			7	
				mp3	y y y	, y	y y	<u>,</u>					
				TAUAUA	y y y	y	y y	y	y n			y	
	6 8 2	1 2	1 2 2	iner	y y y	y	y y	y	y n				
	nterval between calls	(10 - 60 secs)		Ipog	y y y	y	y y	У	y n	n	n	У	
	1		18 sec	s	y y y	У	n y	n	n n	n	n	n	
17	Fime/Date-	BSC			n y r	у	n y	n	y n	n	n	У	
E)ate: 09/01/2	2003 BSC:	ealing	-Con	dract Filter-			ilter—	Cor			ars —	
T	imeband: 1500-18	00 BSC typ	🖲 suburban	- marine	gold silver bronz	e	gold silv	er bronze	curre	nt device	combi	quota	
E	aytype: weekda	y I		sms	у у у	sms	у	у у	sms	у	у	6	
t		16,23 Click B		voice	у у у	void	e y	у у	voice	у	у	8	
		103 ere Itie/UE		wap	у у у	wap	у	у у	wap	у	y	2	
	remet babe	In Boost	200 y 10-01	fax	у у у	fax	у	y n	fax	у	у	1	
C.				mp3	у у у	mp3	у	y n	mp3	у	y	2	
ch				www	у у у	ww	N y	y y	www	у	у	1	
	Con	tipuo whop re	where	ipeg	y y y	ipeg	y j	y y	ipeg	у	y	2	
	53011	unde when re	auy	video	у у у	vide	o y	y n	video	y	у	2	
FC	urrent Even	t									_		
Us	er Type: Initiator:	Receiver:	Service:	Event Ty	pe: Device Typ	: Make/M	odel:	Call duration	1 C	all End Tin	ne:	15:	:00:00
[go	Id 20156701	202768761	35	end	laptop	Dell Insp	aron 5000	5	SECS	4:59:05			
-	data	line band	Distance -		1 time		- ile - time	august.					
•	09/01/2003	0000-0300	30796563303	229390322	21 00:01:00	SE VC	nvicetype	start		1			<u> </u>
	09/01/2003	0000-0300	30796563303	229390322	21 00:01:10			end]			
-	09/01/2003	0000-0300	57397584439	348921147	11 00:02:00	VC	bice	start		-			
-	09/01/2003	0000-0300	5/397584439	348921147	11 00:02:08			end		-			
-	09/01/2003	0000-0300	20256847085	573975845 573975945	13 00:03:00	VC	lice	start		-			-
-	103/01/2003	0000-0300	20230047003	1073373649	13 00.03:08			end			_		

The MSC managed the ten base stations and 180 callers each making calls generated by the call generator shown above

The MAC manages calls and applies special filters on the basis of CODA intelligent advice

The MSC is a 'cell', with a status log, failure log and filter settings, just like the BSC

The special filters are shown here

ocation UK		BW free	300	Lines free	100	Date	09/01/2003	Connected	3577	Colutions
Active y		BWYello	w 20	Lines Yellow	6	Day Type	weekdav	Rejected	1469	
Online y		BW red	10	Lines red	3	Timeband	1500-1800	Diverted	16	
ystem Da	ata Sto	re •			•	C	omplete			×
date	timeba	and large	initiator	receiver	time	servicetune	levent	1		
09/01/2003	1500-	1800	20711037191	80057712022	18:00:16	loor noogpo	end			
09/01/2003	1500-	1800	80057712029	20056556585	18:00:18		end			
09/01/2003	1500-	1800	29076439765	80057712022	18:00:24		end			
09/01/2003	1500-	1800	80057712028	20176730885	18:00:24		end			
09/01/2003	1500-	1800	80057712036	80057712025	18:00:25		end			
09/01/2003	1500-	1800	94196554548	21899301207	18:00:27	-	end			
09/01/2003	1500-	1800	80057712025	94196554452	18:00:29		end			
09/01/2003	1500-	1800	20176730885	85307772018	18:00:33		end			
09/01/2003	1500-	1800	23236098185	94196554548	18:00:35		end			
09/01/2003	1500-	1800	30796563292	30796563302	18:00:39		end			
09/01/2003	1500-	1800	22196367211	34892131311	18:00:42	1	end			
09/01/2003	1500-	1800	23533164185	ISP	18:00:44		end			
09/01/2003	1500-	1800	29076439754	20711037191	18:00:46		end			
09/01/2003	1500-1	1800	80057712031	34892121351	18:00:50	3	end			
09/01/2003	1500-	1800	74696554521	57397584379	18:00:56		end			
09/01/2003	1500-	1800	21453702201	57397584679	18:01:01		end			
09/01/2003	1500-	1800	85307772017	20859570193	18:01:02		end			
09/01/2003	1500-	1800	29076439759	29076439757	18:01:04		end			
09/01/2003	1500-	1800	85307772011	55196554494	18:01:19		end			5
city	westend	aylesbu	ry chelmsf	ord luton	maidenhead	tilbury	barking	ealin	g finchley	umts
ee lines ee bandwidth	72	Special Filt sms Gold I Silver I Bronze I Blocks 1	voice wap fax voice wap fax v v v v v v v 3 2 3	mp3 www.jpeg	video VI VI VI VI VI					

Successful calls are logged here

Filter settings are decided by intelligence cells at the higher layers

This diagram shows the flow iof intelligence and how it can be delivered transparently



The system is able to respond to non linear waves of calls effectively by imposing crisis filters

Monitoring Ops Layer - Proce	ss Descriptions			
Crisis Management				
Special filters are calculate Special filter is sent to BSC Special filter is sent to MD during crisis sent reduced	d for each BSC and timeban Defore time band starts at start of timeband OR login special filter	d by Mon Mons layer by anal NOR mid timeband whenever	ysis of comparable earlier tir MD changes BSC OR MD r	ne band requesting call connection
Special Filter (opportune Extra services offered by s	nity): pecial filter if spare capacity a	at each BSC		
Special Filter (threat): If BSC in crisis (detected u Mon Ops Layer sends sna	ising CSFs) then reduced filte pshot of BSC to Mon Mons la	er reset mid timeband and ser ayer to provide a response ba	nt to any user requesting cal sed on a thorough analysis.	Il connection.
Meanwhile Mon Ops Layer	applies crude fast crisis resp	onse mechanism, progressiv	ely blocking:	
Level 1 block s shut do	ervices offered in excess of contra wn existing calls in excess of contr	uct act (filter not involved)		
Level 2 block n block r	np3, video, jpeg, fax, wap, www.to.k np3, video, jpeg, fax, wap, www.to.s	oronze users silver users		
<u>Level 3</u> block n block v block v	np3, video, jpeg, fax, wap, www.to.g roice to bronze users roice to silver users	gold (not incl gold999) users		
<u>Level 4</u> block v block n block s block s	oice to gold (not incl gold999) user np3, video, jpeg, fax, wap, www.to.g ims to bronze users ims to silver users	rs gold24c users		
<u>Level 5</u> block v block s block n block s block v block s	oice to gold24c users ims to gold (not incl gold999) users np3, video, jpeg, fax, wap, www to g ims to gold24c users oice to gold999 users ims to gold999 users (no further cut	jold999 users s possible)		
If crisis level > 2 then instru	uct gold999 and gold24c MDs	s to switch to UTMS (if they re	quest connection and have	UTMS capability)
In crisis BSC goes to level automatically moves down	1 automatically, and alerts hu settings until crisis subsides	uman operator to select crisis	setting with v short time out	in which case it
Authentication	Start Call	End Call	Manage Crisis	

Crisis filters ensure that users get services albeit reduced to voice and sms for many – we have assumed that this is preferable to total loss of service –privileged users retain all services



CODA Green Adaptive Response

The CODA Green responses are based on complex data analysis which allows the system to make predictions on the data.

Available gree	en		Max use	dl%	special filt	e
16/01/2003	lines	bw	lines	bw	Larger revision	
city	18	68	61.1%	48.5%	61.1% Expand	
westend	18	68	61.1%	50.0%	61.1% Expand	
aylesbury	7	35	85.7%	60.0%	85.7% Expand	
chelmsford	7	35	100.0%	62.9%	100.0% No change	
luton	7	35	100.0%	65.7%	100.0% No change	
maidenhead	7	35	100.0%	65.7%	100.0% No change	
tilbury	7	35	100.0%	60.0%	100.0% No change	
barking	12	50	91.7%	76.0%	91.7% Expand	
ealing	12	50	91.7%	78.0%	91.7% Expand	
finchley Recommenda	12 tion:	50	91.7% alter spec	76.0% al filters a	91.7% Expand s suggested	

Recommendations are based on analysis by usage, comparison and forecasting cells.

Analysis is carried out on call data which is structured carefully to ensure that only mission critical data reaches the intelligence cells

	Α	В	С	D	E	F	G
1	date	timeband	initiator	receiver	time	servicetype	event
2	09/01/2003	1500-1800	57397584679	94196554116	15:00:14	video	start
3	09/01/2003	1500-1800	20036527535	29076439762	15:00:15	jpeg	start
4	09/01/2003	1500-1800	57397584519	80057712027	15:00:17	voice	start
5	09/01/2003	1500-1800	34892127991	23533164185	15:00:18	jpeg	start
6	09/01/2003	1500-1800	20265438185	30796563288	15:00:19	jpeg	start
7	09/01/2003	1500-1800	34892124671	30796563288	15:00:20	video	start
8	09/01/2003	1500-1800	85307772014	85307772016	15:00:21	jpeg	start
9	09/01/2003	1500-1800	63636907657	29076439756	15:00:22	voice	start
10	09/01/2003	1500-1800	85307772006	20136672785	15:00:23	voice	start
11	09/01/2003	1500-1800	20056556585	57397584359	15:00:24	video	start
12	09/01/2003	1500-1800	63636907655	30796563301	15:00:28	jpeg	start
13	09/01/2003	1500-1800	21602235203	ISP	15:00:30	wap	start
14	09/01/2003	1500-1800	20136672785	80057712026	15:00:34	voice	start
15	09/01/2003	1500-1800	34892134631	85307772013	15:00:36	video	start
16	09/01/2003	1500-1800	57397584519	80057712027	15:00:36		end
17	09/01/2003	1500-1800	17896554427	34892141271	15:00:38	voice	start
18	09/01/2003	1500-1800	63636907647	34892141271	15:00:40	jpeg	start
19	09/01/2003	1500-1800	29076439757	20116905185	15:00:42	voice	start
20	09/01/2003	1500-1800	30796563288	23087565223	15:00:42	voice	start
21	09/01/2003	1500-1800	63636907652	34892151231	15:00:44	voice	start
22	09/01/2003	1500-1800	29076439763	17896554431	15:00:45	video	start
23	09/01/2003	1500-1800	63636907647	34892141271	15:00:45		end
24	09/01/2003	1500-1800	30796563302	42196554476	15:00:46	voice	start
25	09/01/2003	1500-1800	85307772006	20136672785	15:00:46		end
26	09/01/2003	1500-1800	80057712022	29076439754	15:00:48	jpeg	start
27	09/01/2003	1500-1800	85307772014	85307772016	15:00:50		end
28	09/01/2003	1500-1800	42196554476	94196554116	15:00:51	jpeg	start
29	09/01/2003	1500-1800	20036527535	29076439762	15:00:52		end
30	09/01/2003	1500-1800	85307772009	20176730885	15:00:54	voice	start
31	09/01/2003	1500-1800	80057712034	ISP	15:00:56	www	start
32	09/01/2003	1500-1800	20056556585	57397584359	15:00:56		end
33	09/01/2003	1500-1800	20236818035	34892137951	15:00:57	jpeg	start
34	09/01/2003	1500-1800	20265438185	30796563288	15:00:57		end
35	09/01/2003	1500-1800	57397584389	34892137951	15:01:00	video	start
36	09/01/2003	1500-1800	63636907646	ISP	15:01:00	www	start
37	09/01/2003	1500-1800	63636907652	34892151231	15:01:02		end
38	09/01/2003	1500-1800	34892141271	29076439756	15:01:03	video	start

CODA is able to deal with vast amounts of data by suing 'forgetting' algorithms based on cognitive models.

Conclusions and Future Work

The CODA concept of automated response in an adaptive intelligence cycle has been successfully demonstrated and proved in so far as it is possible to show a complex system response

Further work involves applying CODA to real systems such as third generation mobile networks

It involves adding more sub-systems and co-ordinating them using the higher layers.



The CODA structure is based on cognitive models of the human brain

Feedback Loop



Layer

At the higher command and control layers, CODA should be capable of simple speech based interactions

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