

Approach to Remote Participation in the ITER experimental program. Experience from model of Russian Remote Participation Center.

13th IAEA Technical Meeting on Control, Data Acquisition and Remote Participation for Fusion Research 5-8 July 2021, Culham Centre for Fusion Energy, Culham, UK

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Background and Objectives



ITER project has a lot of plasma diagnostics and technological systems Procurement Arrangements with all members. In nearest future (even today) we will need remote functions for commissioning of these PA's, future monitoring in scope of warranty coverage, maintenance support and ITER scientific collaboration.

From 2018 Russian Domestic Agency works on Prototype of Remote Participation Centre that covers these tasks to study and solve problems and borders on this way.

We do this work with ITER IO CODAC team and ITER IT Team. Work done under contract H.4a.241.19.18.1027 with ROSATOM and Task Agreement C45TD15FR with ITER Organization

Technical and scientific tasks to study



- Modeling of Remote Participation Center
- Interconnection with ITER networks. Security issues in accordance with the requirements of cyber security standards. VPN, firewalls and routing challenges.
- Investigation of the data transfer via existing public networks (reliability, speed accuracy, latency, volume dependence, public networks interconnections problems and etc.)
- Test of ITER remote participation interfaces (Unified Data Access servers, Data Visualization and Analysis tools, etc.). Access to experimental data.
- Exploring the boundaries of participation. What we can and cannot do remotely.
- Participation in ITER main control room activities (remote copy of central screens and diagnostics HMI) and intercommunication.
- Local data processing with integration of existing data processing software (visualization, analysis, etc.) and Local Large-capacity data storage system.

The Remote Participation Center Model room



2018 – first approaches.



2019, 2020 – modeling.



TODAY - remote participation.









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The Remote Participation Center Model room

- Room with a total area of about 40 square meters. Including a server room of about 4 square meters.
- 7-8 places in RPC. Three dedicated roles.



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NSTITUTION PROJECT

CENTER ITER

Network zoning in ITER

- ITER infrastructure zoning is assumed in accordance with the requirements of information security and IEC 62645 standard. This standard defines three security degrees (S1, S2 and S3), to which graded security requirements. ITER defined these zones and graded security requirements related to them as follows:
 - S1 Safety systems (POZ)
 - S2 Conventional controls & interlocks (POZ)
 - S3 External to POZ zone (XPOZ)

ITER go further - Anything outside S3 on ITER Site is IT zone. Remote participants moved to XPOZ DMZ zone between IT and S3.

See more info of Network Zoning and User Classes in D.Stepanov - Remote Participation in ITER Systems Commissioning - this meeting



RPC Model public networking

For testing purpose we create 2 separate L3 VPN over 2 separate connections to European Internet.

- via ROSTELECOM from TRINITI (Troitsk) to STOKHOLM GTT TER ONE public internet exchange point.
- via National Research Center «Kurchatov Institute» (Moscow) to GEANT exchange point in AMSTERDAM.

Distance from RF RPC to ITER IO for data travel is more than 3000 kilometers.



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5	187.74	144.00	60	187.90	31.61

Links latency and hops



ROSTELECOM from TRINITI to IO - 66.9 ms average

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	IP:	193.51.56.19												100m	5 200ms
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1	244	192.168.254.2	54		192.168.254.254				1,0	0,4	1,3		9 ⊢1		
2	244	46.61.168.225			46.61.168.225				1,3	0,0	1,4		e , − .		
3	244	94.25.20.69			94.25.20.69					3,2	3,8		*		
4	244	95.167.95.138			95.167.9	5.138			4,5	3,2	22,8		é ×		
5	244	87.226.133.111	L		tkm-cr4.intl.ip.rostelecom.ru			24,0	21,1	23,8	0,820	19-			
6	244	77.67.90.96			ae1-500.cr1-stk3.ip4.gtt.net				24,3	22,0	23,0	1,230	x		
7	244	213.200.119.2	14		et-3-3-0.cr4-par7.ip4.gtt.net					50,6	57,0			- M	
8	244	77.67.123.206			renater-gw-ix1.gtt.net					52,4	60,4			HOX	
9	244	193.51.180.16	7		193.51.180.167					68,5	69,0)e-	
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11	244	193.51.177.71			te0-0-0-2	0-0-2-ren-nr-cadarache-rtr-091.noc.renater.fr			70,6	68,3	69,3			xò	
12	244	193.51.186.65			iter-vl999-po1-cadarache-rtr-021.noc.renater.fr				71,2	70,0	71,3				4
13											*	100,000		/	
14	244	193.51.56.19			iter.org				66,9	64,0	69,0			i ok -i	
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et-3-3-0	.cr4-par3	7.ip4.gtt.net (21	3.200.119.214) ho	op 7										10 minutes (11:52:	17 - 12:02:17)
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0		11.53.00	11.54.00	11.55.00		11.55.00	11.53.00	11.0	0.00		1.00.00		13.00.00	12.01.00	12.02
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iter.org	193.51.5	6.19) hop 14												10 minutes (11:52:	:17 - 12:02:17)
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10		11:53:00	11:54:00	11:55:00		11:56:00	11:57:00	11:5	8:00	1	1:59:00		12:00:00	12:01:00	12:02
				Image	generate	d by PingPlot	ter Windows 5.18.2	.8159 Pro	(http://	pingplo	tter.com	1)			

L3 VPN tunnel Latency between host in RPC and edge host in IO 66.4 ms average.

National Research Center «Kurchatov Institute» to IO 65.0 ms average

Targe	: Name: IP:	Iter.org 193.51.56.19														100ms	200ms
Samples	Timed:	03.09.2020 13:34:4	4 - 03.09.202	20 13:39:44													
Hop	Count		IP			Name				Avg	Min	Cur	PL%		Latency Gra	aph	99ms
1	121	10.106.14.254			10.106.14	.254				1,4	0,4	1,4		-			
2	121	144.206.226.61			vr2-itr1.gr	id.kiae.ru				1,7	0,0	1,0		¢			
3	121	62.40.125.122			kiae.mx1.	kiae.mx1.ams.nl.geant.net					0,6	0,8		8-1			
4	121	62.40.125.121			kiae-gw.m	kiae-gw.mx1.ams.nl.geant.net					40,0	42,4					
5	121	62.40.98.129			ae9.mx1.k	on.uk.geant.n	iet			48,5	46,7	48,8) (Hereit		
6	121	62.40.98.37			ae6.mx1.k	on2.uk.geant.	net			49,4	48,0	48,9			k.		
7	121	62.40.98.179			ae5.mx1.p	oar.fr.geant.ne	t			56,4	54,0	55,5) e)	
8	121	62.40.124.70			renater-lb	1-gw.mx1.par	.fr.geant.net			56,8	54,7	55,5			×	2	
9	121	193.51.180.167			193.51.18	0.167				65,7	64,3	64,9				> p	-
10	121	193.51.177.222			xe1-0-1-m	harseille1-rtr-	131.noc.renat	er.fr		64,7	62,7	63,5				×	
11	121	193.51.177.71			te0-0-0-2-	te0-0-0-2-ren-nr-cadarache-rtr-091.noc.renater.fr						70,6				- <mark>♦ ×</mark> ⊣	
12	121	193.51.186.65			iter-vl999-		64,9	63,8	66,5				_ k —⊣				
13		-										*	100,0				
14	121	193.51.56.19			iter.org					65,0	63,2	64,6					
								Round Trip (I	ms)	65,0		64,6			Focus:	13:34:44	13:39:44
kiae-gw.1 90	nx1.ams	.nl.geant.net (62.40.:	125.121) hop	4											5 minutes	(13:55:30	- 14:00:30) 30
1:4	13:	35:00 13:35:20	13:35:40	13:36:00	13:36:20	13:36:40	13:37:00	13:37:20	13:3	7:40	13:38	1:00	13:38:	20 13:38:40	13:39:00	13:39:20	13:3
ae5.mx1	par.fr.ge	ant.net (62.40.98.179	9) hop 7												5 minutes	(13:55:30	- 14:00:30)
90																	30
0	1 12.	35:00 12:25:20	12:25:40	12.26.00	12.26.20	12.26.40	12:27:00	12.27.20	12.2	7.40	12.9	2.00	12.20	20 12.29.40	12.20.00	12.20.20	12.0
+.+	narseille	1-rtr-131 noc repater	13.33.40 fr (193.51.1)	77 222) hon 1	0	13.30.40	13.37.00	13.37.20	13.3	7.40	13.3	5.00	13.30	20 13:38:40	5 minutes	13:39:20	- 14:00:30)
90										~~~		~					30
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90 0	193.51.5	6.19) hop 14													5 minutes	: (13:55:30	- 14:00:30) 30
4:4	0 13:	35:00 13:35:20	13:35:40	13:36:00	13:36:20	13:36:40	13:37:00	13:37:20	13:3	7:40	13:34	3:00	13:38	20 13:38:40	13:39:00	13:39:20	13:3

L3 VPN tunnel Latency between host in RPC and edge host in IO 68.5 ms average.

L3 VPN speed test - single and multi stream



ROSTELECOM from TRINITI (Troitsk) to STOKHOLM GTT TER ONE Single stream:



Multi streams:



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National Research Center «Kurchatov Institute» (Moscow) to GIANT Single stream:







L3 VPN results



- Latency is not a subject to worry inside L3 VPN.
- In general, the test shows that you we get about 25 stable megabits per second from IO to RPC within one TCP-IP stream.
- More or less stable full channel load approached at 24-28 simultaneous streams.
- Increasing the number of concurrent data streams allows for better performance in a tunnel where regular public(channel) providers are used. At the same time, more channel providers and traffic exchange points on the path of packets show more pronounced the effect. This effect probably in a peculiarities of channel providers bandwidth shaping, which underestimate the speed of one stream in order to prevent channel congestion and provide a more or less uniform bandwidth for all users. We think, dedicated L2-level channels will not be associated with such a feature.

Case of remote operation

For use case of operation – remote user (operator) observes and controls some system on IO side. We perform test works with "DNFM reference diagnostic" system. The idea: remote user (operator) observes and controls DNFM reference diagnostic system and uses Skype for Business for parallel communication.

CASE A

For participation environment, we look for three cases:

- A. NX access to DNFM reference diagnostic over public internet using CODAC Development NX-Access.
- B. Teradici software client over dedicated network connection.
- C. Teradici hardware client over dedicated network connection.







TITUTION PROJECT

Remote operation results



- Both NX and Teradici solution is useable for remote access to DNFM reference diagnostic.
- Teradici hardware client is more usable in Remote Participation Center if we need stationary workstation and Teradici software client is useless because it has no advantages in comparison with NX.
- NX is more flexible solution for remote participation outside the X.XPOZ zone or other dedicated network.
- These tests show also that communication (audio and video) between 2 groups and Screen sharing solution have to be investigated more deeply.

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Live participation

One of the main task of the Remote Participation Center is direct participation during the experiment, together with the main control room, as well as direct participation in various acceptance tests and commissioning. The goal is to provide participants with a fully immersive experience as if they were in the main control room.

Our experiments have shown - most stable and flexible option for demonstrating live data and creating a control room effect is the **EPICS gateway** for mimics and **ITER dashboard** for live data graphics.

In addition, **EPICS gateway** allows you to create, emulate and test your own mimics using ITER live data.

More on EPICS gateway - Study on EPICS Communication over Long Distance. L. Lobes - this meeting





Remote Participation Center today



Today RF DA using Model of Remote Participation Center for live experiments. As example - number of successful remote experiments at IBR-2M reactor at Frank Laboratory of Neutron Physics (Dubna, Russia) and Neutron Generator at TRINITI (Troitsk, Russia) for testing some elements of ITER diagnostics. Our experience has shown that this experimental method is convenient. Allows to reduce unnecessary trips to the site of the experiment and at the same time does not reduce the effect of being present at the experimental stand.



Next step - Russian Remote Participation center for ITER 🥥

- Creation time 2023-2024
- Room with a total area of about 140 square meters.
- Server room of about 100 square meters.
- More places for participants in RPC.
- 2 separate WAN 10 Gigabit each.
- L2 tunnel to ITER.

And more...



Information and communication space for fusion research in the Russian Federation



- Federal program. Creation time 2021-2024.
- Remote Participation centers in all major Institutions of fusion research in Russia.
- Joint laboratories based on existing and future experimental installations and stands with remote access from all RF Remote Participation centers.
- HPC cluster for data analysis and computing.
- Portal with experimental data, scientific publications, electronic reference books, list of scientific and experimental equipment and other public information.
- Joint planning and conducting remote scientific experiments, support for scientific decision-making, information interaction within the framework of experimental programs on controlled thermonuclear fusion.

Thank you!

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