



# Web-service for FPGA synthesis using ARC-powered grid infrastructure

**Andrii Salnikov<sup>1</sup>, Anatolii Davydenko<sup>2</sup>**

<sup>1</sup>National Taras Shevchenko University of Kyiv, Ukraine; e-mail: [manf@grid.org.ua](mailto:manf@grid.org.ua)

<sup>2</sup>Pukhov Institute for Modeling in Energy Engineering, Kyiv, Ukraine; e-mail: [davidenkoan@gmail.com](mailto:davidenkoan@gmail.com)

NorduGrid 2017  
Tromsø, Norway



## Applied Project Overview

- ❑ Research project conducted in the Pukhov Institute for Modeling in Energy Engineering (NAS of Ukraine)
  - ❑ **Goal:** develop FPGA-based intrusion detection systems (IDS) for data networks
  - ❑ *create an FPGA configuration based on the signatures database*
  - ❑ *apply this configuration to the all FPGA-based IDS systems in the enterprise network on regular basis*





## Applied Project Overview

- ❑ Research project conducted in the Pukhov Institute for Modeling in Energy Engineering (NAS of Ukraine)
  - ❑ **Goal:** develop FPGA-based intrusion detection systems (IDS) for data networks
  - ❑ *create an FPGA configuration based on the signatures database*
  - ❑ *apply this configuration to the all FPGA-based IDS systems in the enterprise network on regular basis*
- ❑ Complexity
  - ❑ getting FPGA configuration from VHDL estimated as  $O(n^2)$
  - ❑ signatures database can hold millions of records
  - ❑ synthesis of FPGA configuration on every signatures update
  - ❑ lot of resources are needed to support such network





## Applied Project Overview

- ❑ Research project conducted in the Pukhov Institute for Modeling in Energy Engineering (NAS of Ukraine)
  - ❑ **Goal:** develop FPGA-based intrusion detection systems (IDS) for data networks
  - ❑ *create an FPGA configuration based on the signatures database*
  - ❑ *apply this configuration to the all FPGA-based IDS systems in the enterprise network on regular basis*
- ❑ Complexity
  - ❑ getting FPGA configuration from VHDL estimated as  $O(n^2)$
  - ❑ signatures database can hold millions of records
  - ❑ synthesis of FPGA configuration on every signatures update
  - ❑ lot of resources are needed to support such network
- ❑ **The idea**
  - ❑ create a central service for FPGA configuration synthesis
  - ❑ reuse existing ARC-powered grid infrastructure in Ukraine as resources pool

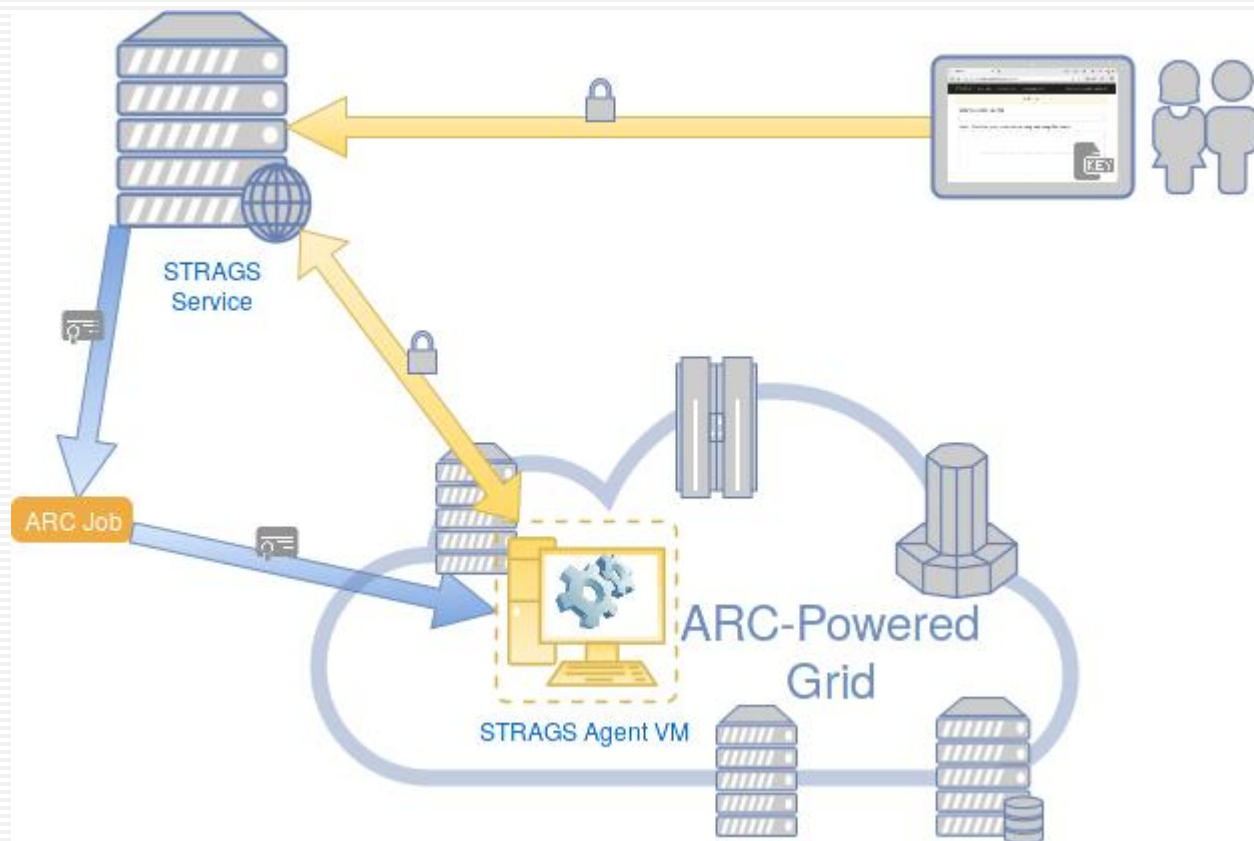




## Security Tasks Reconfigurable Accelerators Grid-Service

### ❑ STRAGS components

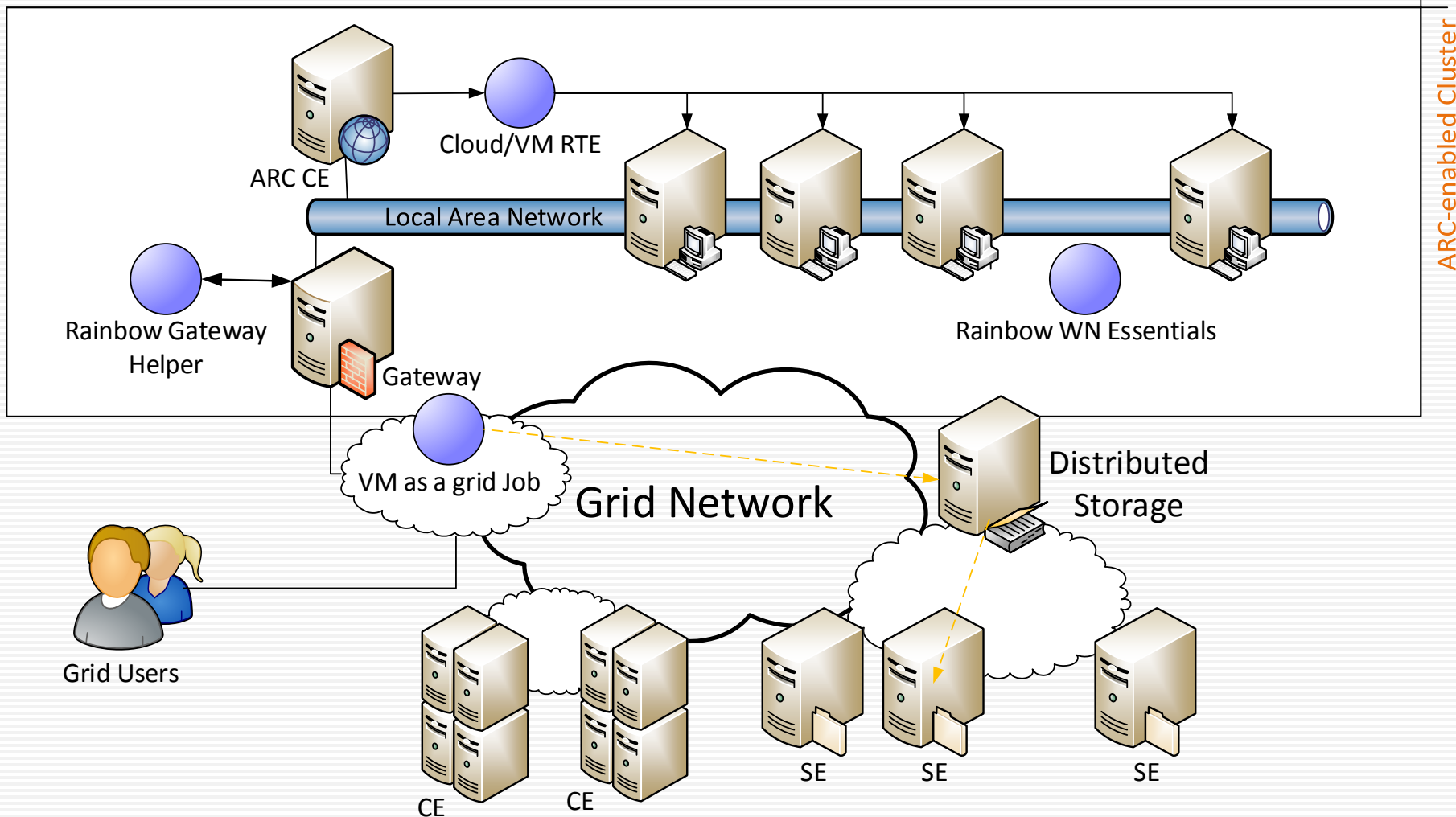
- ❑ ARC CEs
- ❑ STRAGS Service
  - ❑ FPGA Jobs
  - ❑ ARC Jobs
- ❑ STRAGS Agent VM
  - ❑ Pilot Agent
  - ❑ Pre-installed software
- ❑ Rainbow ("ARC in the Cloud")
  - ❑ VM lifecycle





# Web-service for FPGA synthesis using ARC-powered grid infrastructure

## Rainbow (“ARC in the Cloud”) Framework





# Web-service for FPGA synthesis using ARC-powered grid infrastructure



## FPGA Synthesis as a Service

STRAGS Add job **Active jobs** Finished jobs Admin Interface Welcome, Andrii Salnikov!

### Active jobs

| # | Name          | Status               | Progress                   |
|---|---------------|----------------------|----------------------------|
| 1 | FPGA test job | Running par (router) | <div><div></div></div> 74% |

DEMO

STRAGS Add job Active jobs Finished jobs Welcome, Andrii Salnikov!

### Finished jobs

Show 10 entries


Search:

| # | Name          | Actions   |
|---|---------------|---|
| 1 | job1          |         |
| 2 | test2         |     |
| 3 | FPGA test job |     |

Showing 1 to 3 of 3 entries

Previous 1 Next

You have chosen to open:

 **result.bit**  
which is: HTML document (277 KB)  
from: <https://moldyngrid.org>

What should Firefox do with this file?

- ☒ Open with Firefox (default)
- ☐ Save File
- ☐ Do this automatically for files like this from now on.

Cancel

OK

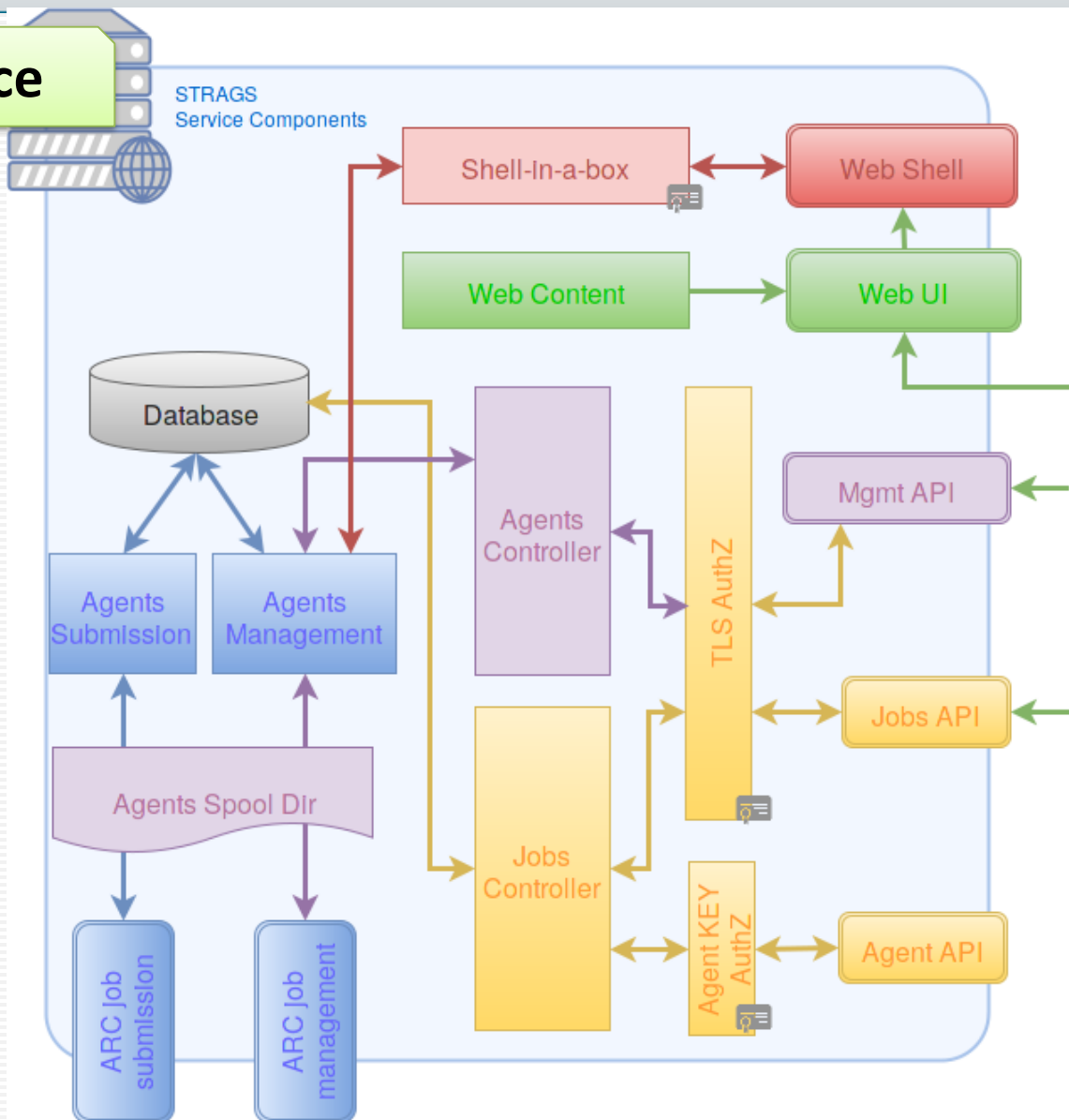


# Web-service for FPGA synthesis using ARC-powered grid infrastructure



## Under the hood of service

- ❑ **Jobs and Management REST API**
  - ❑ UI is completely separated
  - ❑ X509
- ❑ **Agents REST API**
  - ❑ For pilot VMs
  - ❑ PSK
- ❑ **ARC clients**
- ❑ **Shell-in-a-box**

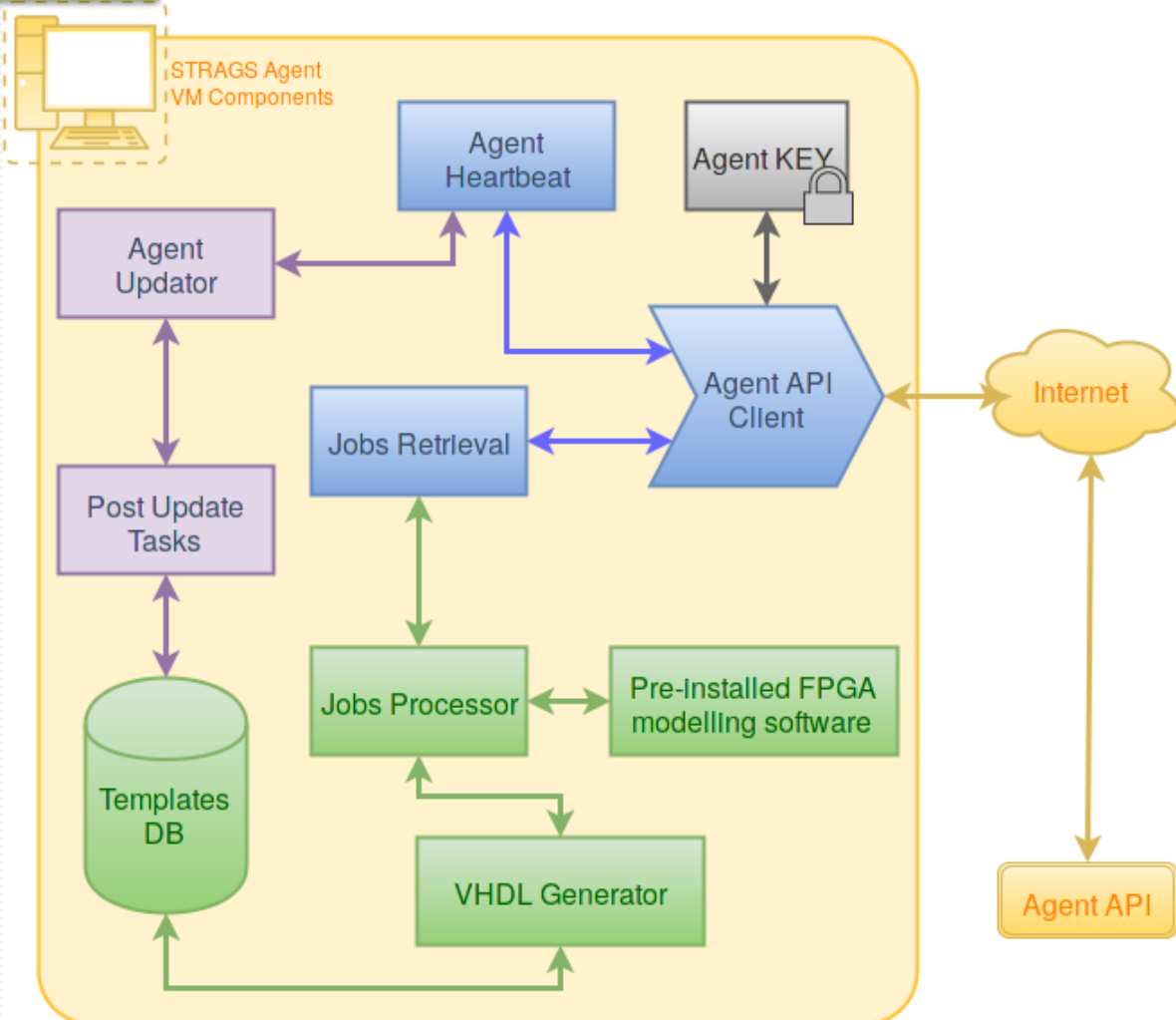






## Under the hood of agent

- ❑ **Pre-installed software for FPGA modelling**
  - ❑ +own components for VHDL generation from templates
- ❑ **Agent updater**
  - ❑ No need to rebuild VM image
  - ❑ Updates itself
  - ❑ Invoke any command on post-install to modify VM image
- ❑ **Jobs management**





# Web-service for FPGA synthesis using ARC-powered grid infrastructure



## Interactive access capabilities

### Controls:

Standby agents:

### Agents:

Show  entries

| # | Status  | Location          | Heartbeat           | Actions |
|---|---------|-------------------|---------------------|---------|
| 1 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:02 |         |

root@strags:~ - Shell... x

https://strags.matmoden.kiev.ua:8443/W5QTCZUVLFqnB/

```
root    10899  0.0  0.0  5660  1164 ?      Ss   Dec15   0:00  crond
root    10999  0.0  0.1  13548 2556 ?      Ss   Dec15   0:00  /usr/libexec/postfix/ma
postfix 11002   0.0  0.1  12808 2672 ?      S    Dec15   0:00  \_ qmgr -l -t fifo -u
postfix 32678  0.0  0.1  12732 2524 ?      S    Dec15   0:00  \_ pickup -l -t fifo -
root    11040  0.0  0.0  12892  792 ?      S<s1 Dec15   0:00  auditd
STRAGS Rainbow VM [ ~ ]# ll /opt/STRAGS
total 52
drwxr-xr-x 2 root root 4096 Nov 19 2015 cron.d
-rwxr-xr-x 1 root root 1246 Nov 29 12:37 genvhd.sh
drwxr-xr-x 2 root root 4096 Dec 15 09:25 postupdate
-rwxr-xr-x 1 root root  551 Nov 15 02:58 run_agent_update.sh
-rwxr-xr-x 1 root root  128 Nov 15 03:05 run_postupdate.sh
-rwxr-xr-x 1 root root 2927 Nov 29 12:48 run_xilinx.sh
-rwxr-xr-x 1 root root 1336 Nov 15 03:06 StragsCommon.py
-rw-r--r-- 1 root root 1638 Dec 15 09:25 StragsCommon.pyc
-rwxr-xr-x 1 root root  228 Nov 15 03:00 StragsHeartbeat.py
-rwxr-xr-x 1 root root 2378 Nov 15 01:35 StragsJobAgent.py
-rwxr-xr-x 1 root root  275 Dec  3 2015 StragsReporter.py
-rw-r--r-- 1 root root  9 Nov 29 12:48 version
drwxr-xr-x 2 root root 4096 Nov 29 12:38 vhd
STRAGS Rainbow VM [ ~ ]#
```

Get debug access to the agent shell



## Conclusions

- ❑ Proposed implementation had proven the possibility to solve the FPGA synthesis tasks using the grid infrastructure resources powered by the Nordugrid ARC middleware.
- ❑ The flexibility of ARC CE allows to run VM as a grid jobs with a minimal amount of extra components provided by Rainbow (“ARC in the Cloud”) framework.
- ❑ ARC-powered infrastructure can efficiently operate with CPU-intensive not-portable software complexes like FPGA synthesis software.



## Followups

- ❑ Proposed approach as well as most part of the developed services code can be easily adopted for similar tasks that involves a pool of submitted virtual machines with interactive access capabilities.
- ❑ There are planned development and deployment of STRAGS-based system in the National Taras Shevchenko University of Kyiv aimed to use ARC-powered grid resources as a pool of VMs for Linux labs.



**Thank you for kind attention!**



# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



STRAGS Add job Active jobs Finished jobs Admin Interface

Welcome, Andrii Salnikov!

## Add job

Enter name for new job

FPGA test job

Select file from your computer or drag and drop file below

Just click and select file from your computer or drag and drop file here



# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



STRAGS   Add job   Active jobs   Finished jobs   Admin Interface   Welcome, Andrii Salnikov!

## Active jobs

| # | Name          | Status      | Progress                  |
|---|---------------|-------------|---------------------------|
| 1 | FPGA test job | Running xst | <div><div>10%</div></div> |

```
top - 10:56:55 up 13 min, 1 user, load average: 0.74, 0.20, 0.06
Tasks: 78 total, 3 running, 75 sleeping, 0 stopped, 0 zombie
Cpu0  : 97.0%us, 2.7%sy, 0.0%ni, 0.0%id, 0.3%wa, 0.0%hi, 0.0%si, 0.0%st
Mem:   1938800k total, 346036k used, 1592764k free, 14868k buffers
Swap:   0k total, 0k used, 0k free, 174676k cached
```

| PID  | USER | PR | NI | VIRT  | RES  | SHR  | S | %CPU | %MEM | TIME+   | COMMAND         |
|------|------|----|----|-------|------|------|---|------|------|---------|-----------------|
| 5015 | root | 20 | 0  | 161m  | 136m | 22m  | R | 85.2 | 7.2  | 0:16.56 | par             |
| 5875 | root | 20 | 0  | 12000 | 4900 | 2596 | R | 0.7  | 0.3  | 0:00.02 | StragsReporter. |
| 5047 | root | 20 | 0  | 11692 | 3392 | 2660 | S | 0.3  | 0.2  | 0:00.02 | sshd            |
| 1    | root | 20 | 0  | 2900  | 1364 | 1168 | S | 0.0  | 0.1  | 0:00.84 | init            |
| 2    | root | 20 | 0  | 0     | 0    | 0    | S | 0.0  | 0.0  | 0:00.00 | kthreadd        |
| 3    | root | RT | 0  | 0     | 0    | 0    | S | 0.0  | 0.0  | 0:00.00 | migration/0     |
| 4    | root | 20 | 0  | 0     | 0    | 0    | S | 0.0  | 0.0  | 0:00.00 | ksoftirqd/0     |



# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)









## Active jobs

| # | Name          | Status               | Progress                   |
|---|---------------|----------------------|----------------------------|
| 1 | FPGA test job | Running par (router) | <div><div></div></div> 74% |

## Finished jobs

Show  entries


Search:

| # | Name          | Actions  |
|---|---------------|--|
| 1 | job1          |             |
| 2 | test2         |         |
| 3 | FPGA test job |     |

Showing 1 to 3 of 3 entries

Previous **1** Next

You have chosen to open:

 **result.bit**  
which is: HTML document (277 KB)  
from: <https://moldyngrid.org>

What should Firefox do with this file?

- ☒ Open with Firefox (default) ▼
- ☐ Save File
- ☐ Do this automatically for files like this from now on.

Cancel OK





# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



## STRAGS Agents Administration

### Controls:

Standby agents:

7

Submit STRAGS Pilot

### Statistics:

Running tasks: 0

Tasks in queue: 0

Agents queue: 65

































### Logs:

Agents submission log

Access log

### Agents:

Show 10 entries

| # | Status  | Location          | Heartbeat           | Actions   |
|---|---------|-------------------|---------------------|---|
| 1 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:02 |             |
| 2 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:01 |             |
| 3 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:02 |             |
| 4 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:01 |             |
| 5 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:01 |             |
| 6 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:01 |             |
| 7 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:01 |     |
| 8 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:01 |     |

Showing 1 to 8 of 8 entries

Previous

1

Next



# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



## Controls:





Standby agents:

7

Submit STRAGS Pilot





## Agents:





Show 10 entries





| # | Status  | Location          | Heartbeat           | Actions   |
|---|---------|-------------------|---------------------|---|
| 1 | Standby | (arc.imbg.org.ua) | 2016-12-15 22:30:02 |     |





```
root@strags:~ - Shell... x
https://strags.matmoden.kiev.ua:8443/W5QTCZUVLFqnB/
root 10899 0.0 0.0 5660 1164 ? Ss Dec15 0:00 crond
root 10999 0.0 0.1 13548 2556 ? Ss Dec15 0:00 /usr/libexec/postfix/ma
postfix 11002 0.0 0.1 12808 2672 ? S Dec15 0:00 \_ qmgr -l -t fifo -u
postfix 32678 0.0 0.1 12732 2524 ? S Dec15 0:00 \_ pickup -l -t fifo -
root 11040 0.0 0.0 12892 792 ? S<sl Dec15 0:00 auditd
STRAGS Rainbow VM [ ~ ]# ll /opt/STRAGS
total 52
drwxr-xr-x 2 root root 4096 Nov 19 2015 cron.d
-rwxr-xr-x 1 root root 1246 Nov 29 12:37 genvhd.sh
drwxr-xr-x 2 root root 4096 Dec 15 09:25 postupdate
-rwxr-xr-x 1 root root 551 Nov 15 02:58 run_agent_update.sh
-rwxr-xr-x 1 root root 128 Nov 15 03:05 run_postupdate.sh
-rwxr-xr-x 1 root root 2927 Nov 29 12:48 run_xilinx.sh
-rwxr-xr-x 1 root root 1336 Nov 15 03:06 StragsCommon.py
-rw-r--r-- 1 root root 1638 Dec 15 09:25 StragsCommon.pyc
-rwxr-xr-x 1 root root 228 Nov 15 03:00 StragsHeartbeat.py
-rwxr-xr-x 1 root root 2378 Nov 15 01:35 StragsJobAgent.py
-rwxr-xr-x 1 root root 275 Dec 3 2015 StragsReporter.py
-rw-r--r-- 1 root root 9 Nov 29 12:48 version
drwxr-xr-x 2 root root 4096 Nov 29 12:38 vhd
STRAGS Rainbow VM [ ~ ]#
```





Get debug access to the agent shell





   





   



# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



STRAGS Add job Active jobs Finished jobs Admin Interface

Welcome, Sergiy Gil

## Agent grid-job stdout

```
Preparing user data to be accessible inside VM (method: DISK)...
  Done.
Prepraing VM system image to run on WN hypervisor...
  Done.
Obtaining network configuration...
  Done.
Starting VM on WN's qemu hypervisor...
  Done.
Waiting for VM network becomes ready...
  Done. Virtual machine IP ping successful.
Waiting for interactive access service starts...
  Done.

-----

You can now connect to VM SSH with the following credentials:
  Address: 194.44.249.94:30006
  Login: root
  Password: Public key authorization only

-----

Going to sleep for VM walltime (87000 seconds)...
```

Close

Access log

8 Standby (arc.imbg.org.ua)

2016-12-15 22:30:01





# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



Add job Active jobs Finished jobs Admin Interface Welcome, S

### Agent grid-job stderr

```
libguestfs: error: mount_ro: mount_ro_stub: /dev/vdb1: No such file or directory  
virt-inspector2: some filesystems could not be mounted (ignored)  
libguestfs: error: size of /usr/share/pixmaps/redhat/shadowman-transparent.png is unreasonably large (21274
```

Close

|   |         |                   |                     |  |
|---|---------|-------------------|---------------------|--|
| 2 | Standby | (arc.imba.org.ua) | 2016-12-15 22:30:01 |  |
|---|---------|-------------------|---------------------|--|



# Web-service for FPGA synthesis using ARC-powered grid infrastructure (BACKUP SCREENSHOTS)



## Agents submission log

```
DEBUG: Removing agents that failed to send heartbeat in 30 minutes
DEBUG: Cleaning obsolete agents directories
INFO: There are already 8 agents in standby (7 configured). Skipping submission
INFO: Starting agent submission cycle at 2016-12-15 22:34:41
DEBUG: Removing agents that failed to start in 24 hours
DEBUG: Removing agents that failed to send heartbeat in 30 minutes
DEBUG: Cleaning obsolete agents directories
INFO: Submitting new agent (8 agents in standby)
DEBUG: Agent UUID e7e5a400-c305-11e6-bf09-525400aaaa02
Your identity: /DC=org/DC=ugrid/O=hosts/O=PIMEE/CN=strags.matmoden.kiev.ua
Contacting VOMS server (named matmoden): voms.grid.org.ua on port: 15127
Proxy generation succeeded
Your proxy is valid until: 2016-12-16 10:34:41
INFO: Configuration (/etc/arc/client.conf) loaded
INFO: Configuration (arc_client.conf) loaded
INFO: Using proxy file: strags.proxy
INFO: Using CA certificate directory: /etc/grid-security/certificates
INFO: Broker Random loaded
INFO: Skipping ComputingEndpoint 'https://arc.imbg.org.ua:60000/arex', because it has 'org.ogf.bes' interfa
INFO: Skipping ComputingEndpoint 'gsiftp://arc.imbg.org.ua:2811/jobs', because it has 'org.nordugrid.gridft
INFO: Skipping ComputingEndpoint 'https://arc.matmoden.kiev.ua:60000/arex', because it has 'org.ogf.bes' in
INFO: Skipping ComputingEndpoint 'gsiftp://arc.matmoden.kiev.ua:2811/jobs', because it has 'org.nordugrid.g
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Failed to submit job description: Service responded with fault: Failed to create new activity. Reques
INFO: Transfer from file:/srv/www/strags.matmoden.kiev.ua/jobs/agents/e7e5a400-c305-11e6-bf09-525400aaaa02/
INFO: Real transfer from file:/srv/www/strags.matmoden.kiev.ua/jobs/agents/e7e5a400-c305-11e6-bf09-525400aa
Job submitted with jobid: https://arc.matmoden.kiev.ua:60000/arex/wnpNDmyurbpnf548lmks8bjnABFKDmABFKDm4DMKD
INFO: Agent submission finished with exit code 0
```