COSMOS/ORBIT Hello-World Tutorial

ORBIT

- Indoor wireless and radio research facility at WINLAB.
- Sandboxes and grid of compute node with various attached HW
  - software defined radios
  - Wireless NICs
  - Bluetooth, IoT
  - etc…
- Allows large-scale experiments
  - proof of concept prototyping
  - network virtualization
  - spectrum utilization
  - etc...

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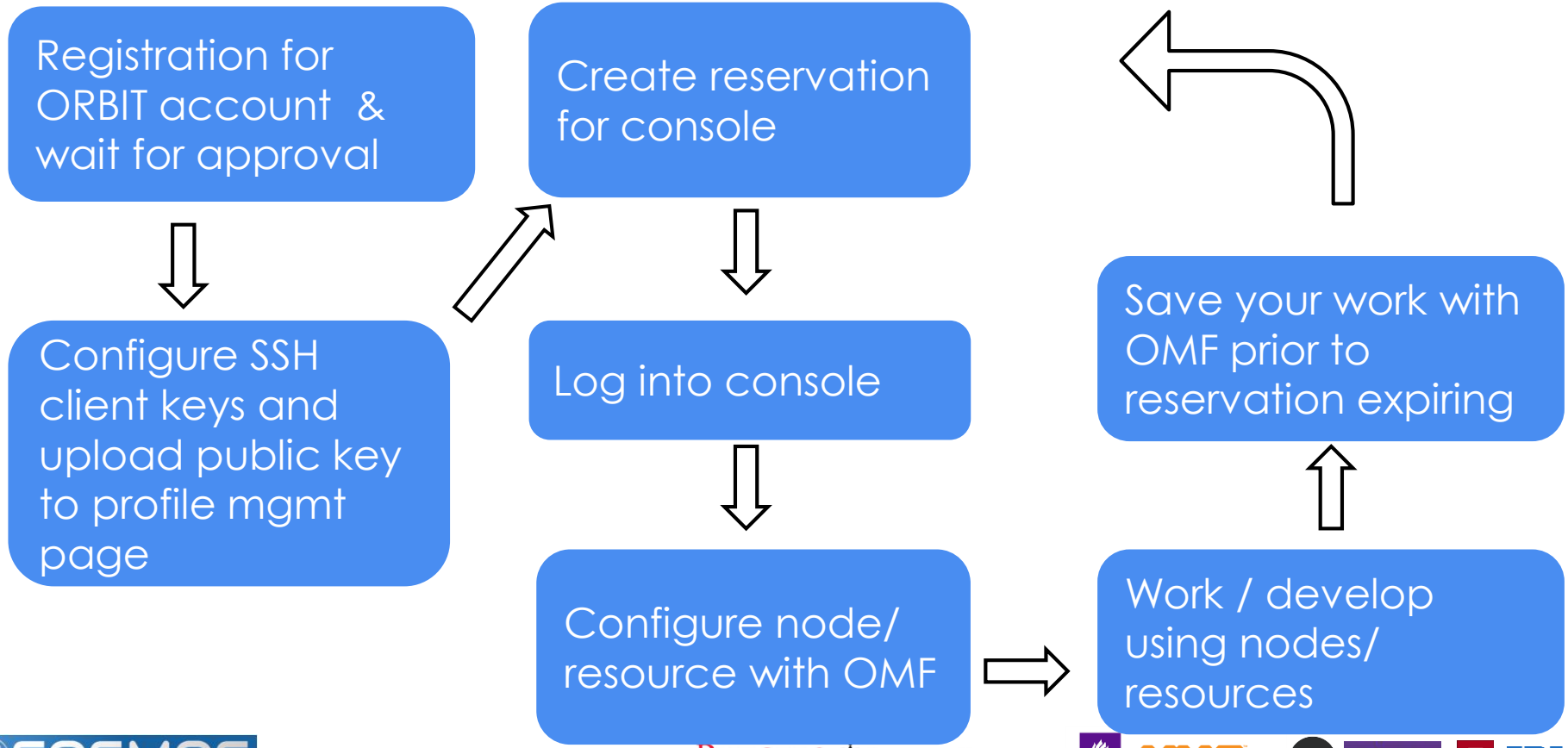
Work Flow Process



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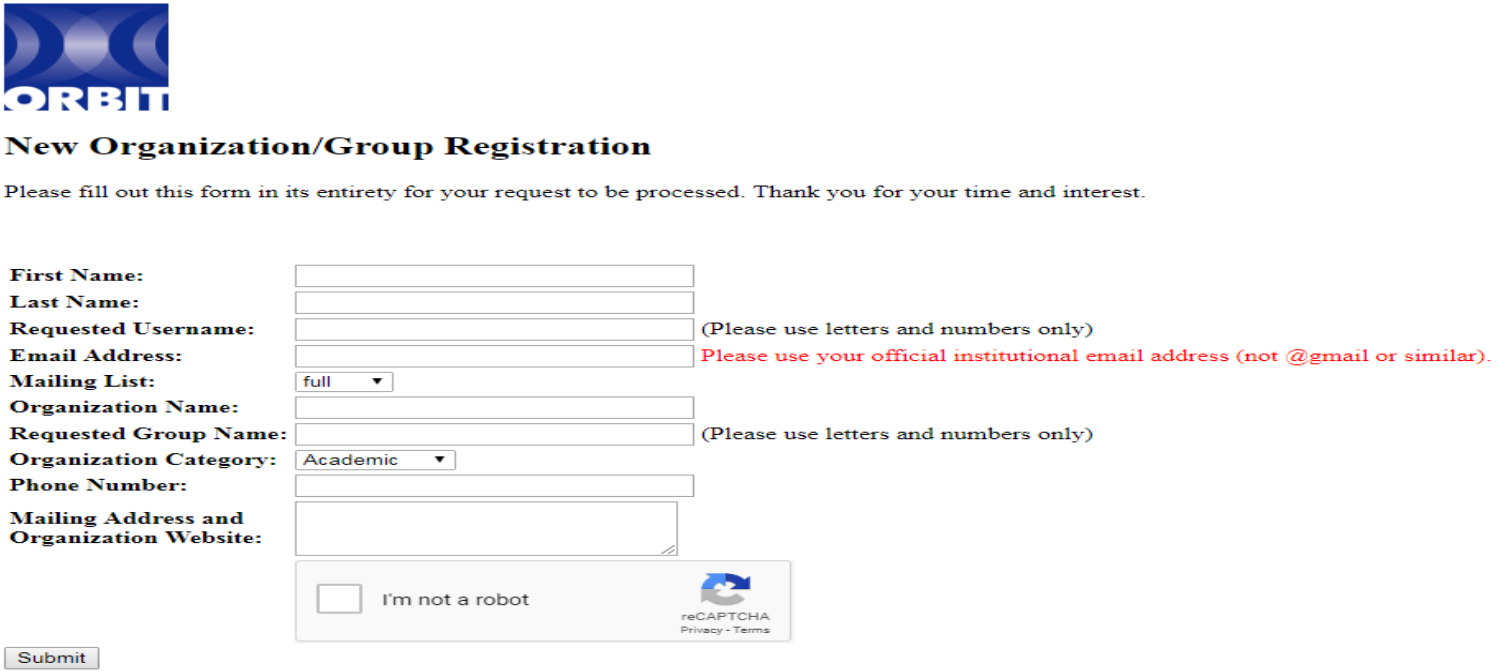
Account Creation, Login (ssh), Scheduler and Status Page

Account Creation

- Account registration and approval
  https://www.orbit-lab.org/userManagement/register



ORBIT

New Organization/Group Registration

Please fill out this form in its entirety for your request to be processed. Thank you for your time and interest.

First Name:		
Last Name:		
Requested Username:		(Please use letters and numbers only)
Email Address:		Please use your official institutional email address (not @gmail or similar).
Mailing List:	full	
Organization Name:		
Requested Group Name:		(Please use letters and numbers only)
Organization Category:	Academic	
Phone Number:		
Mailing Address and Organization Website:		

I'm not a robot

reCAPTCHA
Privacy - Terms

Submit

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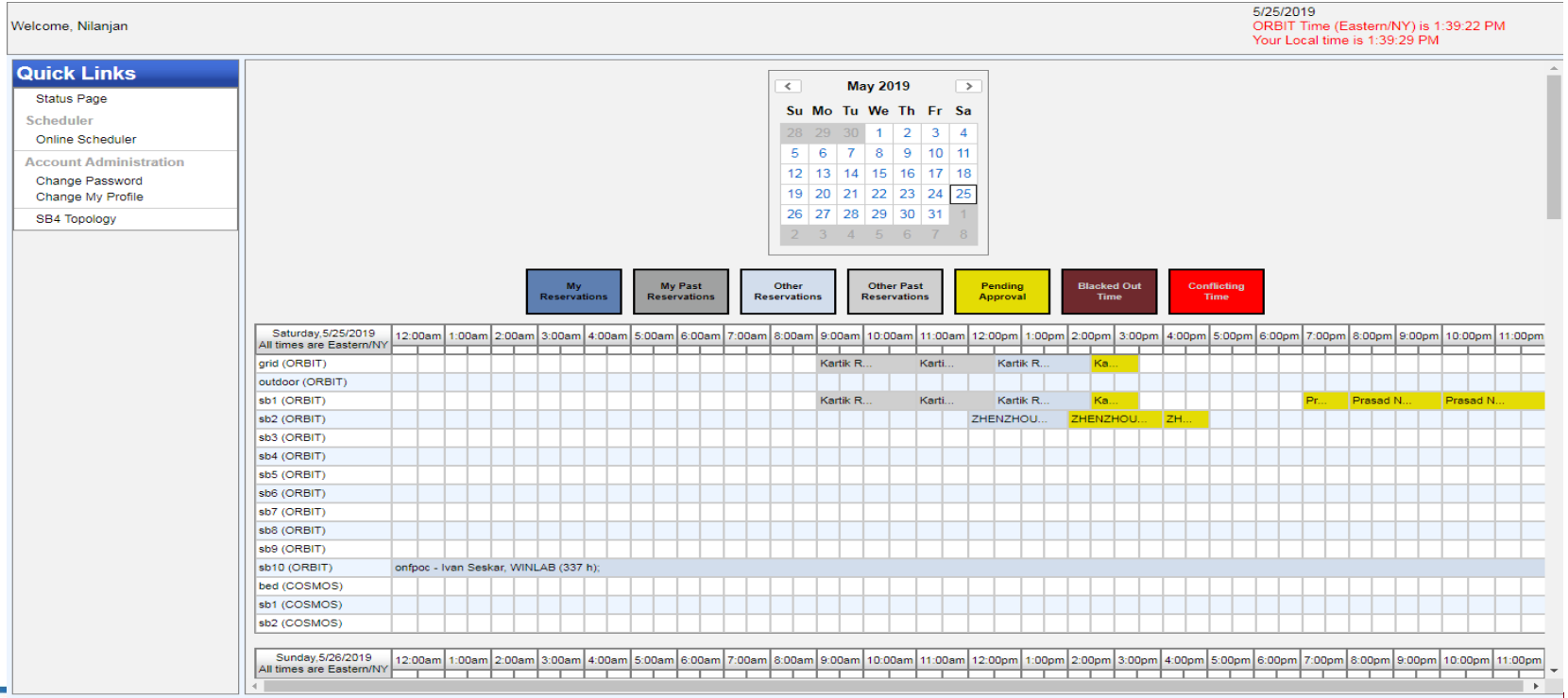
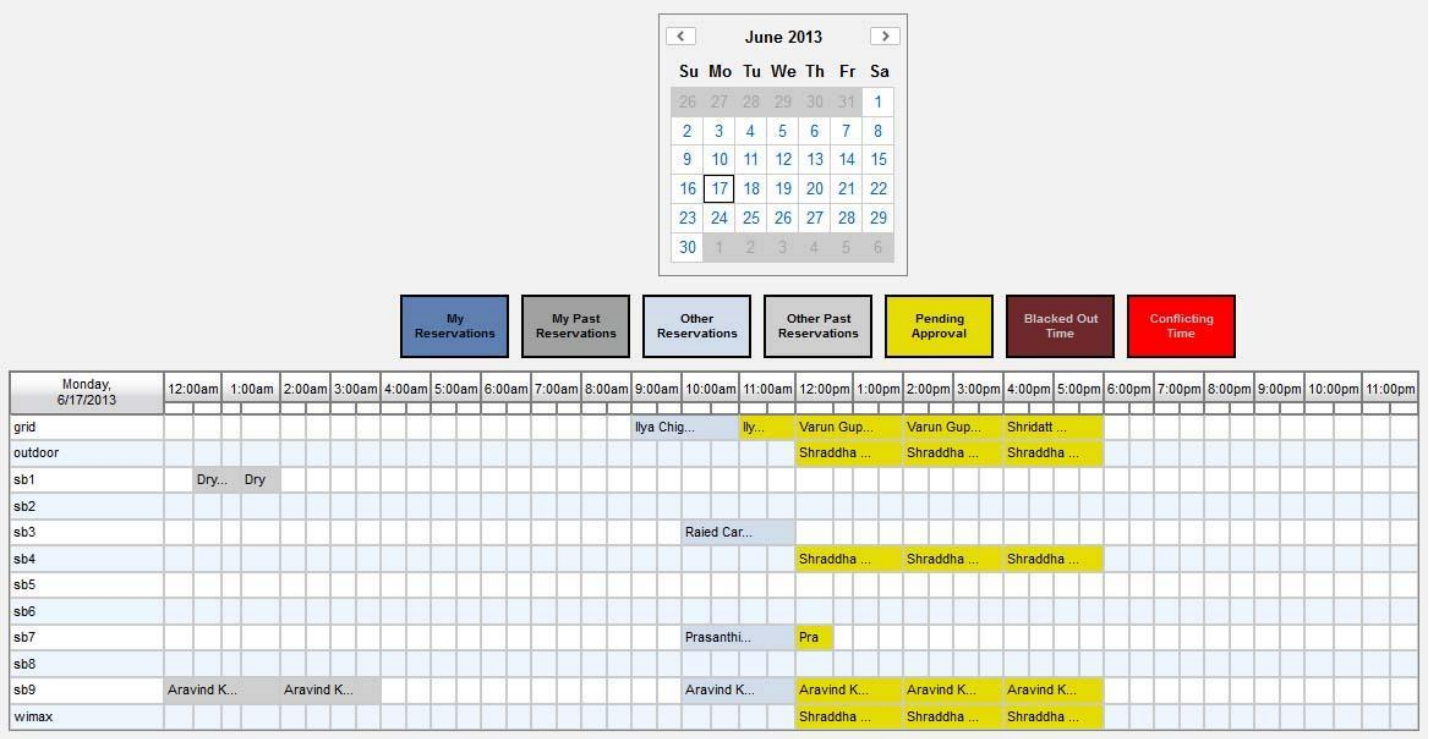
Control Panel

- Resource status & reservation using online scheduler
  https://orbit-lab.org/cPanel/controlPanel/start



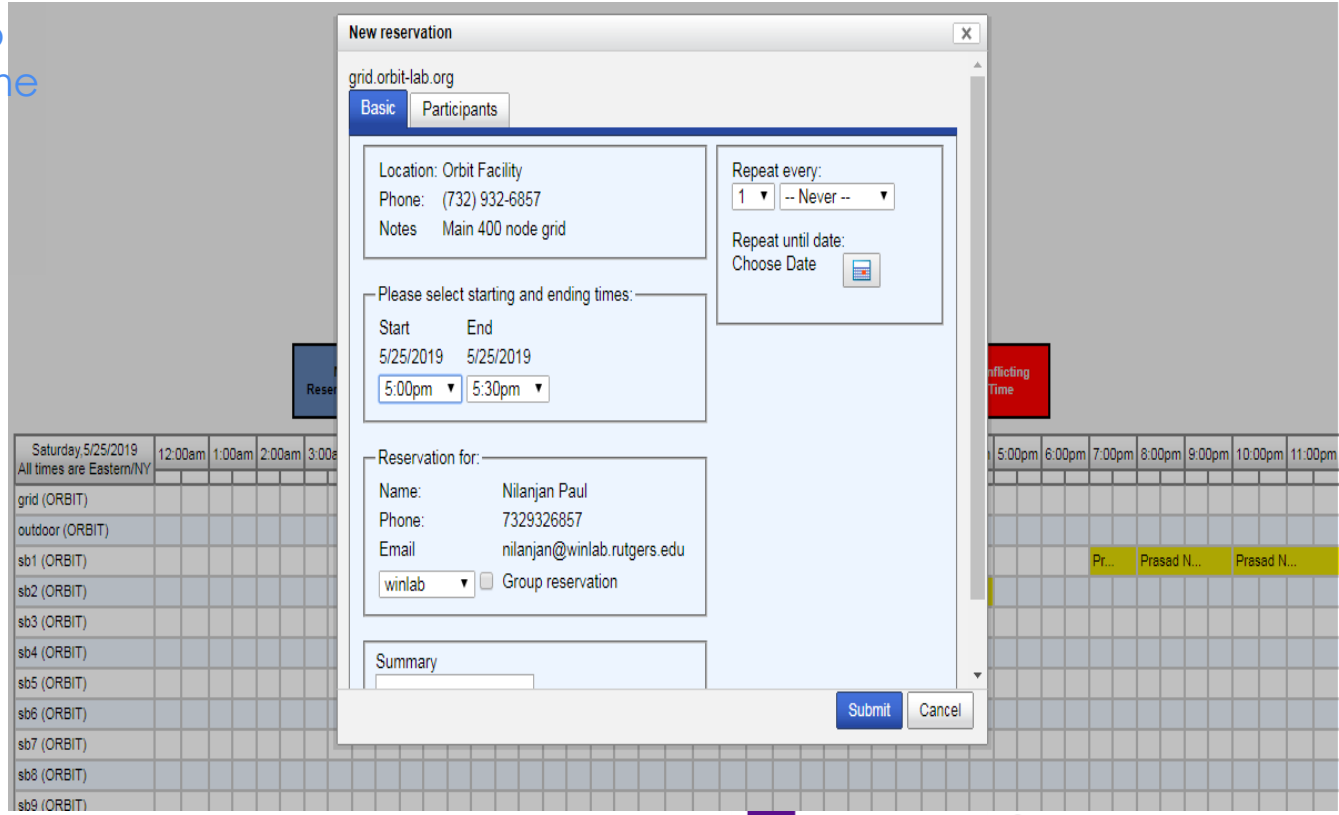
Reservation System

- Calendar based reservation system.
  - Select console & start time for further details.



Reservation System

- New reservation pop-up
  - Start time & end time
  - Max 2 hours
  - Minimum 30 min



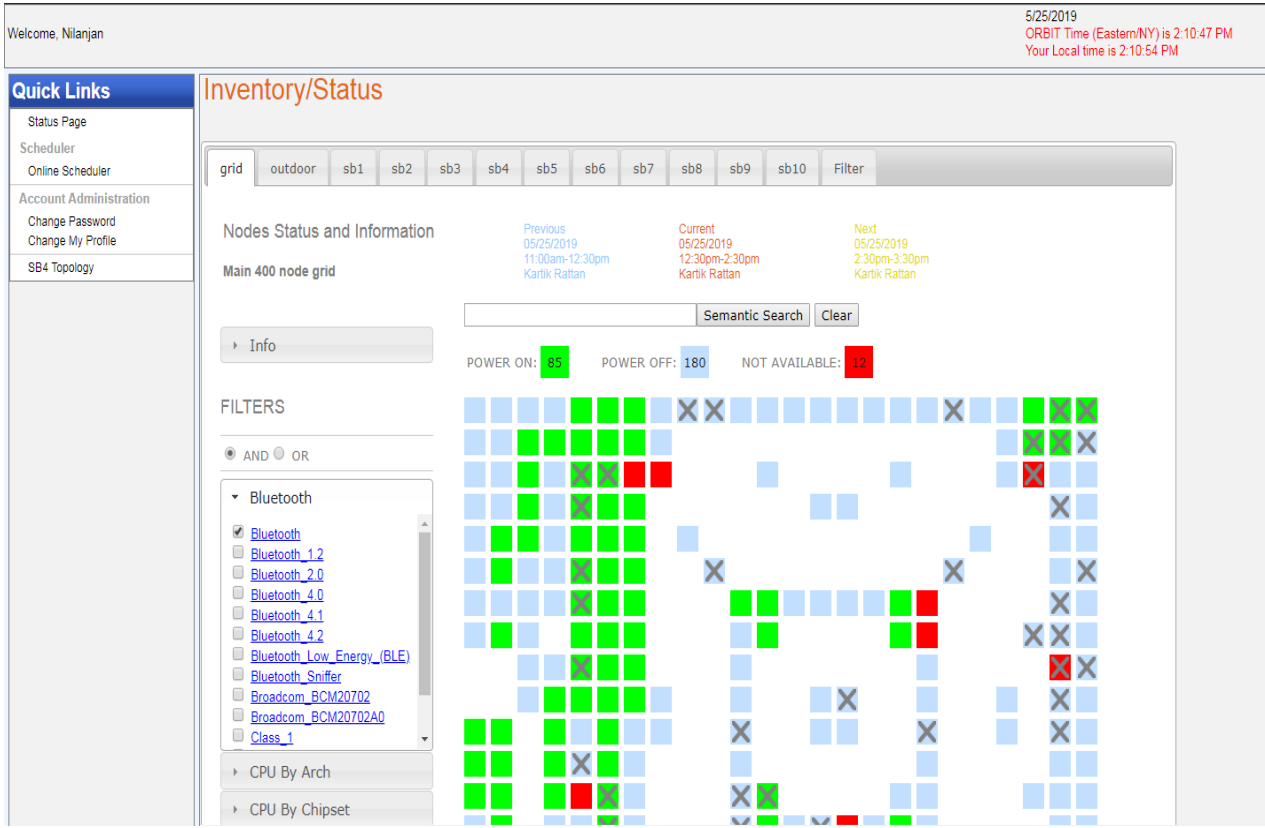
Reservation Auto-approval

- Two stage algorithm:
  - "Early bird" – runs once a day (at 2 PM) and resolves conflicts and approves first two hours for all users for the next day
    - (e.g if you ask for your first slot daily slot from 10-12 the next day , at 2 PM a day earlier you will know whether you got it).
  - "Just in time" – for reservations made after 2 PM or for more than 2 hours per day per domain, the slots will be automatically approved at the beginning of the slot.
- Conflicts are resolved based on usage in the last three weeks
  - (the less you (ab)use it the more likely you are to get it ☺).
- Be aware of major (conference) deadlines

Status Page

Gives a detailed breakdown of deployed resources on the consoles and nodes.

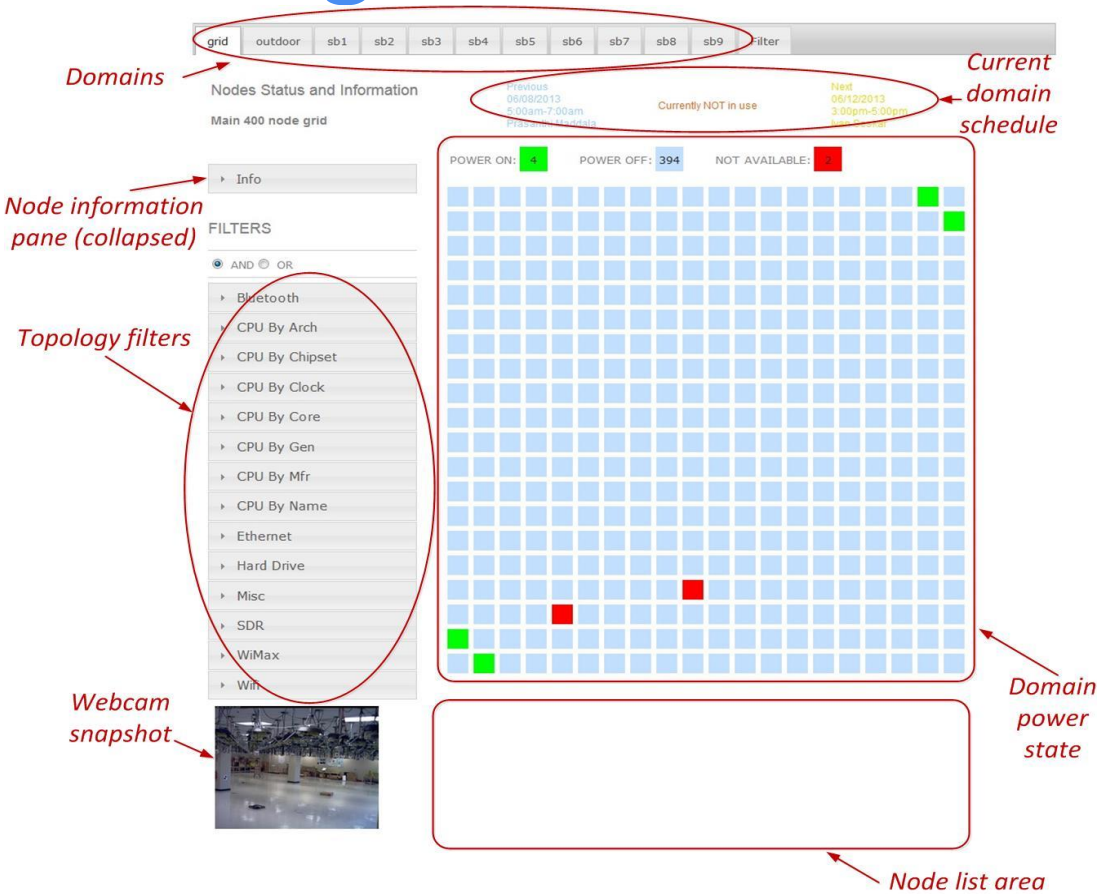
1. Select console tab on top
2. Apply filters of left panels.
3. Provides topology list at bottom of page. (not shown)



Status Page

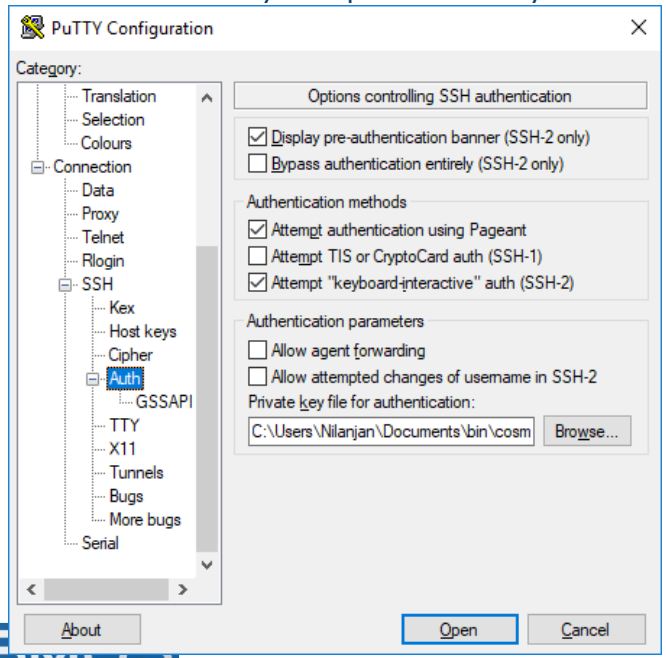
Gives a detailed breakdown of deployed resources on every node.

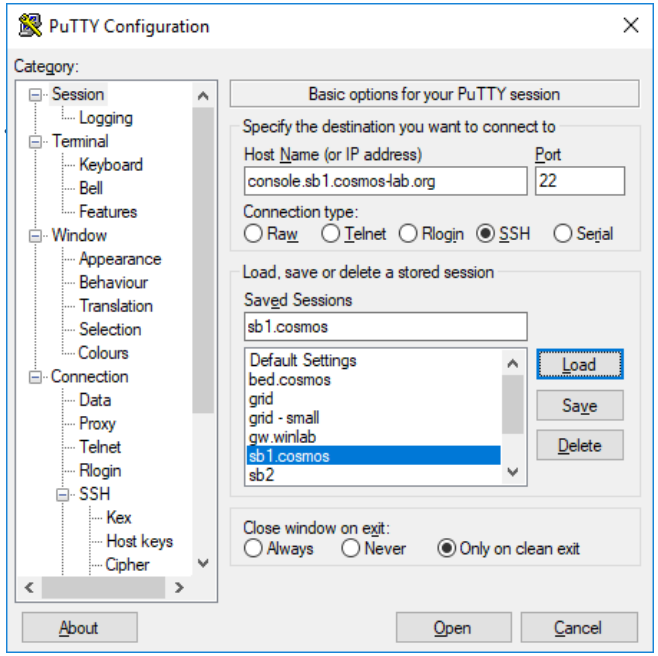
1. Select domain tab on top
1. Apply filters of left panels.
1. Provides topology list at bottom of page (node list area)



Access to console

1. Open putty
2. Enter session info
   - Enter host name of reserved machine.
   - A name for this session
3. Scroll down to SSH → Auth
   - Enter directory for private key file.





4. Connection-->SSH-->X11
   - Enable X11 forwarding
5. Scroll back to session category and hit save, then open the saved session.

Basic OMF commands

omf {tell, stat, load, save}

ORBIT Management Framework

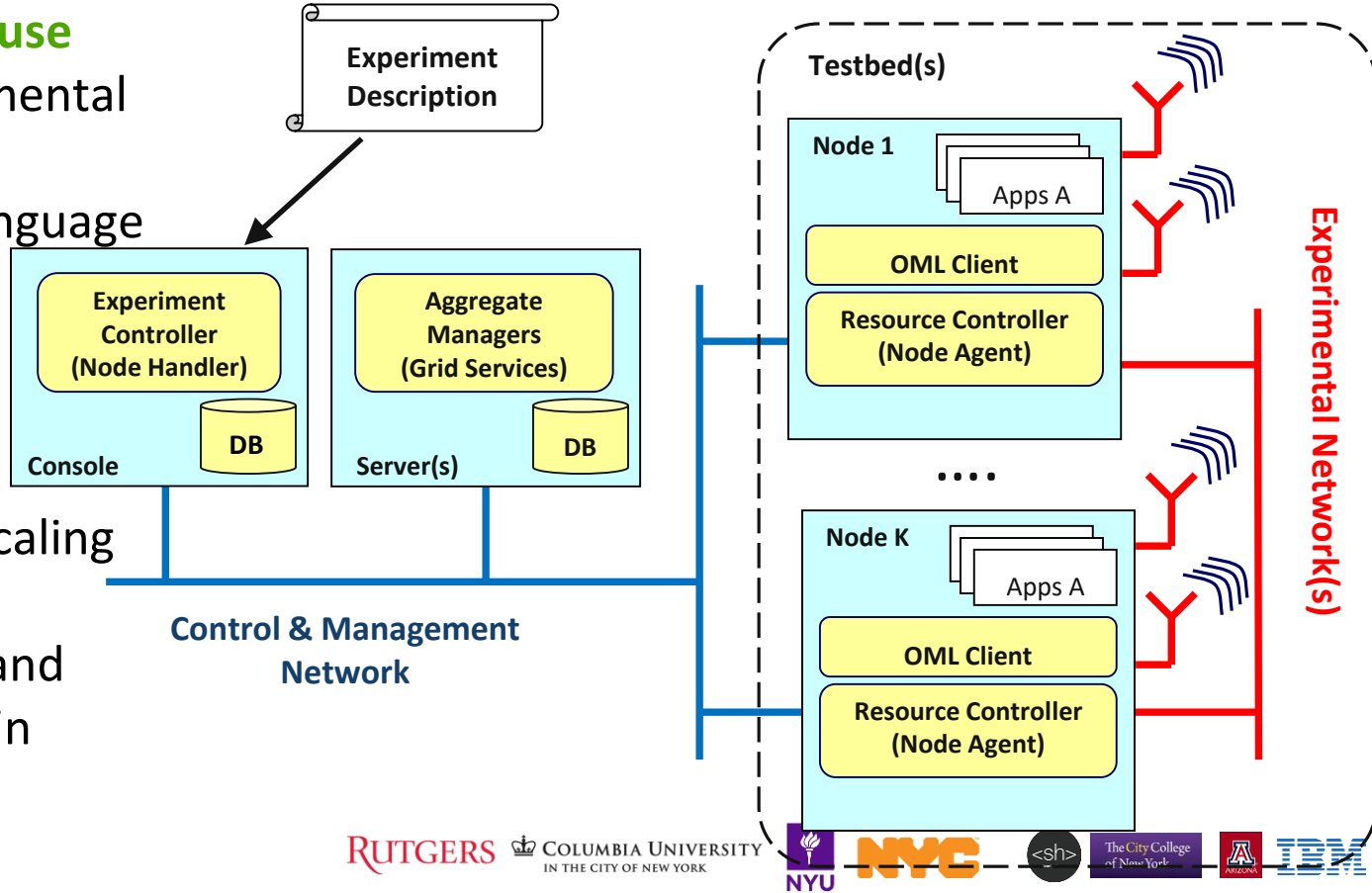
OMF is a framework to **use** and **manage** experimental platforms (testbeds)

-- Developed in Ruby language

-- Single interface in "experiment cycles"

-- Reduce effort while scaling experiments.

-- Allows for validating and reproducing results in same context.



OMF Command

(aka “NodeHandler”)

omf [SUBCOMMAND] [ARGUMENT]...

Subcommand	***Description***
omf help	Display the help for using omf commands.
omf exec	Execute an experiment script.
omf load	Load a disk image on a given set of nodes.
omf save	Save a disk image from a given node into a file.
omf tell	Switch a given set of nodes ON/OFF.
omf stat	Returns the status of a given set of nodes

OMF Sample Runs

A typical set of OMF commands issued by user during a reservation.
Assuming we are using node21-1 & node21-7 on the grid.

- Check status of set of nodes: *omf stat -t node21-1,node21-7*
- Load baseline.ndz image on the nodes: *omf load -i baseline.ndz -t node21-1,node21-7*
- Turn node on: *omf tell -a on -t node21-1,node21-7*

  Work / develop / collect measurements on nodes.

  Note: before saving run */root/prepare.sh* on the node.

- Save node image (only one node): *omf save -n node21-1.grid.orbit-lab.org*

OEDL
in a nutshell

OMF Experiment Description Language (OEDL)

- Domain-specific Language based on Ruby
- Two parts of experiment description (ED):
  - **Resource requirements and configuration**: specifies experimental resources
  - **Task description**: *state-machine* that enumerates tasks to perform

hello-world-wireless.rb

defProperty is used to defined parameters that can be used thought out the scr and passed in via the command line

defGroup is used to define a set of resources that will be prov

configure network resource properties

Sets up application to call within node

What does it do?

```
defProperty('re
sender node")
defProperty('re
receiver node"
defProperty('du
```

```
defGroup('Sender', pr
  node.addApplication("test:app:otg2") do |app|
    app.setProperty('udp:local_host', '192.168.0.2')
    app.setProperty('udp:dst_host', '192.168.0.3')
    app.setProperty('udp:dst_port', 3000)
    app.measure('udp_out', :samples => 1)
  end
  node.net.w0.mode = "adhoc"
  node.net.w0.type = 'g'
  node.net.w0.channel = "6"
  node.net.w0.essid = "helloworld"
  node.net.w0.ip = "192.168.0.2"
end
```

```
  node.net.w0.mode = "adhoc"
  node.net.w0.type = 'g'
  node.net.w0.channel = "6"
  node.net.w0.essid = "helloworld"
  node.net.w0.ip = "192.168.0.3"
end
```

```
onEvent(:ALL_UP_AND_INSTALLED) do |event|
  info "This is my first OMF experiment"
  wait 10
  allGroups.startApplications
  info "All my Applications are started now..."
  wait property.duration
  allGroups.stopApplications
  info "All my Applications are stopped now."
  Experiment.done
end
```

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Now try the running the hello-world-wireless example in the first experiment. Follow the instructions in the tutorial handout.

COSMOS Summary

- Focus on ultra high bandwidth, low latency, edge cloud
- Open platform (building on ORBIT) integrating mmWave, SDR, and optical x-haul
- 1 sq mile densely populated area in West Harlem
- Local community outreach
- Research community:
  - Develop future experiments, provide input
  - (short term) get involved in the educational outreach

More information:

http://advancedwireless.org http://www.orbit-lab.org http://www.cosmos-lab.org
http://omf.orbit-lab.org http://oml-doc.orbit-lab.org

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Appendix

Supplementary information

- Orbit Management frame work (https://omf.orbit-lab.org/)
- OMF Experiment Description Language (https://oml-doc.orbit-lab.org/)

OMF Command

- Find the status of a node or group of nodes in console.
  - omf stat -t TOPOLOGY
- Retrieve status of a single node
  - omf stat –t node21-1
- Specify a comma separated list (no spaces) to get status of multiple nodes.
  - omf stat –t node21-1,node21-2

OMF Command

- Load disk image onto nodes. After load finishes the nodes are turned off.
  - omf load -i IMAGE -t TOPOLOGY
- IMAGE
  - Name of disk image from repository
- Example use
  - omf –i baseline-uhd.ndz –t node21-1.sb1.orbit-lab.org,node21-7.sb1.orbit-lab.org

OMF Command

- Save disk image of a **single** node to repository for later use
  - omf save –n NODE
- NODE
  - Specify FQDN of the node
- Example use
  - omf -n node21-1.grid.orbit-lab.org

OMF Command

- Power cycle nodes or issue reboot
  - omf tell –a ACTION -t TOPOLOGY
- Actions
  - on turns on the nodes
  - offh turns off the nodes
  - reset power cycle the nodes
- Example use
  - omf –a on –t node21-1.sb1.orbit-lab.org,node21-7.sb1.orbit-lab.org

OEDL Commands

8 groups:

- Top-level commands
- Topology-specific commands
- Group-specific commands
- Prototype-specific commands
- Application-specific commands
- Execution-specific commands
- Resource Paths
- Testbed-specific commands

OEDL Top-level Commands: defProperty

defProperty(name, initialValue, description)

- **name**: name of the property. This name will be used to refer to this property in any consecutive OEDL commands.
- **initialValue**: the initial value of the property. This also determines the type of the property.
- **description**: Textual description. Used in Experiment Controller's help message, as well as for the default web interface.

Usage:
defProperty('rate', 300, 'Bits per second sent from sender')
defProperty('packetSize', 1024, 'Size of packets sent from sender')

OEDL Top-level Commands: prop

```
prop.propName
prop.propName = newValue
```

- propName: Name of experiment property.
- newValue: New value to assign to the property.

Usage:

```
defProperty('rate', 300, 'Bits per second sent from
sender') …
'rate' => prop.rate
…
[500, 1000, 2000].each { |newRate|
prop.rate = newRate 14
}
```

OEDL Top-level Commands: logging

```
debug(arg1, ...)
info(arg1, ...)
warn(arg1, ...)
error(arg1, ...)
```

- **arg1**: None or more strings to be logged

Usage:

```
info("Starting")
debug(i, " resource(s) are up")
```

Note: DEBUG and INFO log normal progress and can be ignored, while WARNING and ERROR report on abnormal behavior.

OEDL Top-level Commands: wait

wait(time)

- **time**: pause experiment execution for time seconds

Usage:

```
whenAllInstalled {
...
   [500, 1000, 2000].each { |newRate|
      prop.rate = newRate
      wait 30
   }
}
```

OEDL Topology Commands: defTopology

Used to specify topology consisting of a set of nodes and links each with certain characteristics

```
defTopology( name , arrayOfNodes = nil , &block = nil )
```

- **name**: Name of the defined topology.
- **arrayOfNodes**: (optional) array of resources (e.g. nodes) to include in this topology.
  - the list of valid definition patterns are:
    - [x,y]: Describes a single node at location x@y
    - [x1..x2, y]: Describes a set of nodes along a line starting at x1@y and ending at x2@y. For instance, [2..4, 5] defines the nodes [2,5], [3,5], [4,5].
    - [x, y1..y2]: Same as previous, but for the y coordinate.
    - [x1..x2, y1..y2]: This defines a rectangle area of nodes within the grid.
    - [[x1,y1], [x2,y2], [x3,y3]]: An arbitrary long list of single nodes.
- **block**: (optional) a block of commands that can be used to build/configure this topology.

OEDL Topology Commands: defTopology (cont'd)

Topology Sub-Commands	*Description*
addNode(x,y)	Add node at location x@y to the topology.
removeNode(x,y)	Remove node at location x@y from the topology.
addLink (x, y, spec)	Adds a link between nodes x and y and configures it with the characteristics defined in the 'spec'.'spec' is a hash with the following valid keys {:rate , :per, :delay, :asymmetric}
RemoveLink (x, y)	Severs the link between nodes x and y.
size()	Return the number of nodes in this topology.
getNode(index)	Return the node at the position index in this topology. Return nil if index is greater than the number of nodes in the topology.
getFirstNode()	Return the node at the 1st position in this topology.
getLastNode()	Return the node at the last position in this topology.
getRandomNode()	Return a random node from this topology.
getUniqueRandomNode()	Return a unique random node from this topology. When all the available nodes in this topology have been drawn, this method will return nil and output a warning message to the console.
eachNode(&block)	Execute the commands in block on each node within this topology.
setStrict()	Set the strict flag for this topology. By default, the strict flag is NOT set for a topology.
unsetStrict()	Clear the "strict" flag. By default, the strict flag is NOT set for a topology.
hasNode(x, y)	Return true if the node at location x@y is part of this topology, return false otherwise.

OEDL Topology Commands: defTopology (cont'd)

```
defTopology('test:topo:circle') { |t|
    nodeNum = 8
    xCenter = 10
    yCenter = 10
   radius = nodeNum
   # use simple 4-way algorithm to pick the nodes
   r2 = radius * radius
   t.addNode(xCenter, yCenter + radius)
   t.addNode(xCenter, yCenter - radius)
   (1..radius).each { |x|
       y = (Math.sqrt(r2 - x*x) + 0.5).to_i
       t.addNode(xCenter + x, yCenter + y)
       t.addNode(xCenter + x, yCenter - y)
       t.addNode(xCenter - x, yCenter + y)
       t.addNode(xCenter - x, yCenter - y)
   }
}
```

OEDL Group Commands: defGroup

defGroup(groupName, selector, &block = nil)

- **groupName**: name of the defined set of resources
- **selector**: selects the resources to be contained in this set. Group selector can be also defined with topology URI (i.e. set of nodes that form the topology)
- **block**: instructions for all resources in the group

Usage:

```
defGroup('sender1', [1, 1])      # set contains 1 resource
defGroup('sender2', [2, 1..8]) # set contains  8 resources [2,1], [2,2], ... [2,8]
defGroup('sender', ['sender1', 'sender2', [3, 1..8]]) {|node|
   node.prototype("test:proto:sender", {
      'destinationHost' => '192.168.1.1',
      ...
   }
   node.net.w0.mode = "master" #802.11 Master Mode
}
```

OEDL Group Commands: defGroup (cont'd)

addApplication	Install an application on a node
exec	Execute a command on all nodes in this group.
image	Check whether a node boots in the required image. (not available in version 4.4 of the NH)
netmask	This is the network mask resource path.
onNodeUp	Execute a block of commands when a node is up.
pxeImage(...)	Instructs a resource to boot from a network PXE image (recommended for expert users only).

OEDL Group Commands: group and allGroups

```
group(groupSelector).command()
group(groupSelector).resource_path = value
group(groupSelector).resource_path {...}
```

- **groupSelector:** set of resources to use.
- **command**: command to run for that set.
- **resource_path:** is the parameter to be set
- **value:** is the value to assign to the resource path parameter

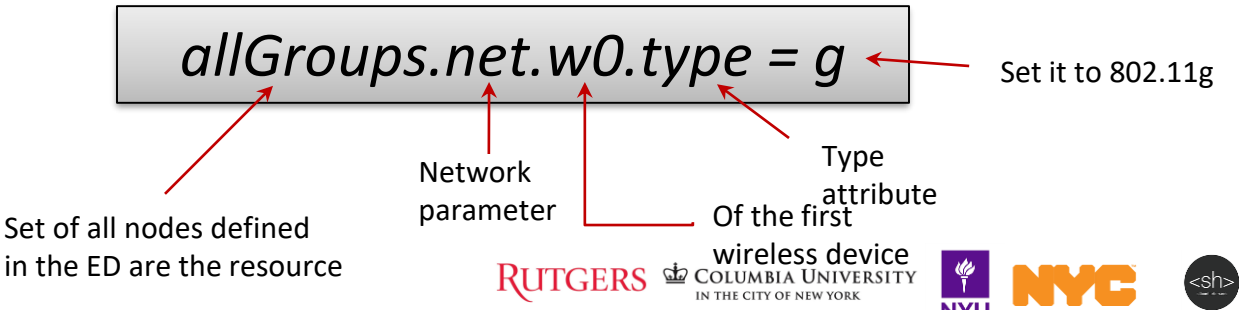
Usage:

```
group('sender1').startApplications
group(['s1', 'r1']).net.w0.essid = "orbit"
allGroups.net.w0 { |w|
   w.essid = "orbit“
}
```

Resource Paths

- A resource path allows the access and the value assignment of a specific configuration parameter of a resource
- **Can be** used in any section of the ED.
- Follow a hierarchical organization:

  <resource_selector>.<hierarchical_path>



net - network resource path

- {e0, e1} Ethernet interface
  - arp = true|false En/disable ARP
  - forward = true|false Enable forwarding
  - ip = address/netmask IP address of interface
  - up = true|false En/disable interface
- {w0, w1} Wireless interface
  - All the above
  - channel (intel only) = 1..11; 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, 161
  - frequency (intel only) = 2.412..2.462GHz (5 Mhz steps); 5.18GHz (20Mhz steps)
  - essid = arbitrary string
  - mode = master|managed|monitor, ad-hoc (intel only)
  - rts (atheros only) = packetSizeThreshold [bytes]
  - rate (intel only) = 1, 5, 11; 6, 9, 12, 18, 24, 36, 48, 54
  - tx_power = -12..15 dBm (intel), 0..20 dBm (atheros)
  - type = a/b/g