FastX Clustering Guide

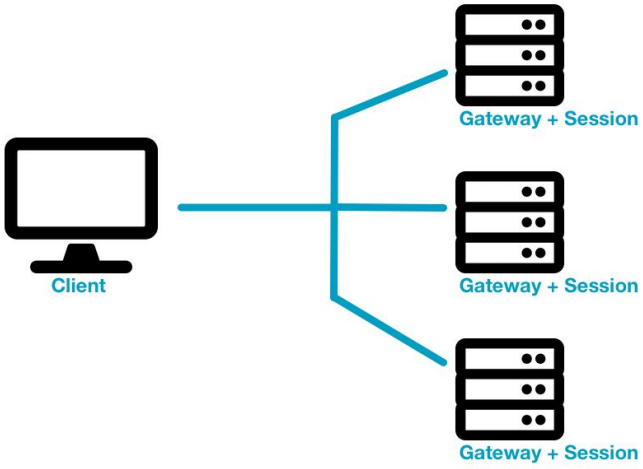
For FastX 3.1

Background

FastX Is a platform for creating, managing, and connecting to Virtual Display Sessions (sessions) on remote Linux systems. Multiple systems can be run individually as standalone systems, but the real power comes from when those systems are linked together into a cluster. Clusters allow administrators to Centrally Manage multiple systems, create single entry points into the cluster event behind a firewall, Load Balance systems to allow even distribution of work, and many other features simplifying and improving the user experience.

An Overview of Cluster Configurations

Default Cluster

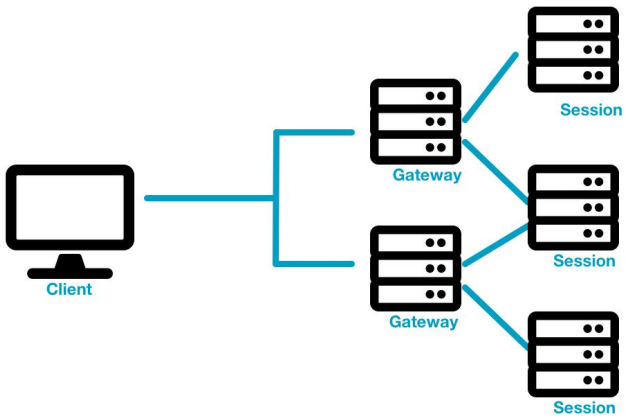


The Default Cluster setup is the basic configuration for clustering. In this setup, the Client (Browser or Desktop) has access to every machine in the cluster (either directly or through a VPN). The purpose of this setup is to connect to any machine and get rerouted if needed to a running session. This configuration is optimal for users who

- have clients that can connect to all cluster members.
- have homogeneous cluster members.

- want a simplified configuration.

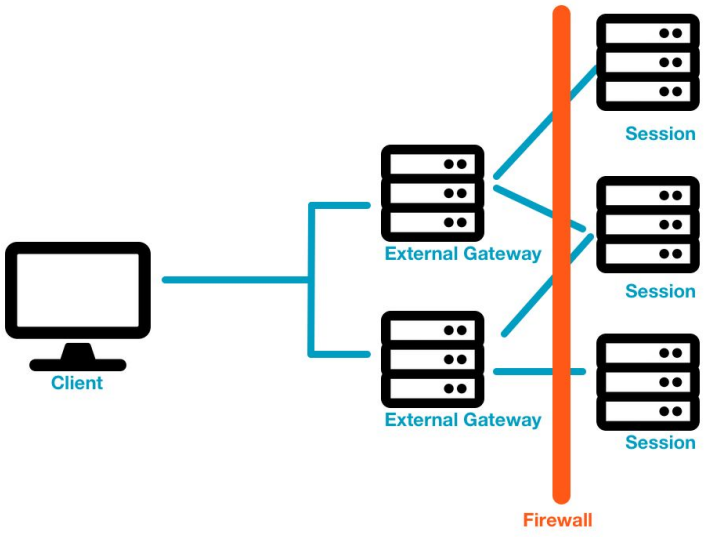
Gateway Cluster



Gateway Clusters add extra gateway servers to the cluster that are used to proxy client requests to the sessions servers. This configuration creates a central access point (of one or more gateway servers) where the clients connect to. No sessions are started on the gateway servers. Gateway servers have direct access to the session servers. However the client may or may not have access to the session servers. This configuration is optimal for users who

- wish to restrict direct access to the session servers.
- have multiple different cluster members.
- want to centralize access to the cluster.

External Gateway Cluster



The external gateway cluster is an extension of the gateway cluster. In this scenario, the gateway servers are on a different network than the session servers. The gateway servers do not have direct access to the session servers. The session servers must be able to connect to the gateway server. The external gateway maintains a connection to each of the members of the cluster. The client makes requests to the external gateway and the gateway proxies the requests to the cluster. This configuration is optimal for users who

- want to isolate the session servers from the outside networks

Best Practices

FastX is designed to be extended into any type of network environment. The default cluster is the preferred configuration as it offers the best performance with least added load on the session servers. Every session server can also act as a gateway server. If the client tries to connect to a session running directly on the cluster member, the cluster member will handle it as if it was a single server setup. If the client connects to Server A and tries to connect to a session on Server B, the client will first try to directly connect to Server B. If that fails, Server A will act as a gateway, proxying the connection to Server B.

The external gateway configuration is typically not recommended unless isolating the session servers on a private network is necessary. External gateway servers must maintain a connection with EVERY other member in the cluster including other external gateways. This can cause added load on the server. Also, since the session server is isolated, all running session connections are proxied through the external gateway which can cause extra load.

The gateway configuration is a hybrid approach where general requests are handled by the gateway server, while the running connections MAY connect directly to the session server. If the client connects to the gateway Server A and attempts to connect to a session on Server B, the client will first attempt to directly connect to Server B. If this fails then Server A will proxy the connection to Server B. The work of proxying the information from the client to Server B can add extra load onto Server A.

Setting Up a Cluster

Server Requirements

Each server in the cluster needs a copy of FastX installed and the web server component must be running. Each server is configured individually allowing for a hybrid cluster. Configuration will be discussed below. Administrators can configure the server using the admin system ui on the web server. The server's configuration file is located in /usr/lib/fastx/var/config/cluster.json

Users need a mounted home directory

Selecting the Servers in a Cluster

The first step in setting up a cluster is to define which servers will be in the cluster. FastX uses a shared distributed database (installed with FastX) for clustering. Any system with access to this shared database is considered a cluster member. Cluster members can be on the same LAN or located externally. Larger installations with multiple user groups may wish to divide their servers into smaller clusters for each group.

Defining the Role of Cluster Members

Once your cluster members have been chosen it is time to define the roles of each member. Technically roles do not exist but logically it is easier to understand how clustering works if we categorize cluster members this way. Each cluster member can take on multiple roles. Roles are defined by the way the cluster member is configured.

Database Access Points

In order to become a member of the cluster, a server needs to sync its local database with a separate cluster member. The cluster member that the server connects to is the Database Access Point. A cluster member does NOT need to connect to every other cluster member, but typically multiple Database Access Points are defined. Database Access Points should have high availability. It is common to use Gateway servers on the LAN as the Database Access Point

Session Servers

Session servers (sometimes called Compute Nodes in HPC terminology) are the workhorses of the cluster. These are the systems that you will be launching sessions on to do work. The entire purpose of a cluster is to find a session server to connect to and launch a FastX session on.

Gateway Servers

Gateway servers are the cluster members that the end user will connect to access the cluster. The gateway can be internal on the LAN or external on the public internet. It can start sessions, or you may configure it to be a pure Gateway and disable logins and starting sessions on it effectively making it a proxy.

External Servers

External servers are the servers that cannot make a direct HTTP connection to other cluster members. They are typically placed on the public internet and act as a pure Gateway server (no logins and no starting sessions) to the Session servers on a LAN behind a firewall. External servers allow administrators to subdivide their cluster across multiple zones keeping the most important information on a private network and restricting access to session servers. External servers maintain TCP connections from every other system in the cluster adding extra load, so these servers should only be configured this way when absolutely needed.

Configuring the Cluster Members

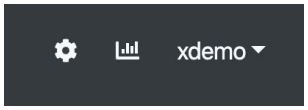
Now that we have divided our cluster members into one or more logical roles, it is time to actually configure the member for the role. Most, but not all, configuration is defined in the Cluster Setup (saved in cluster.json) portion of the Admin section.

Cluster Keys

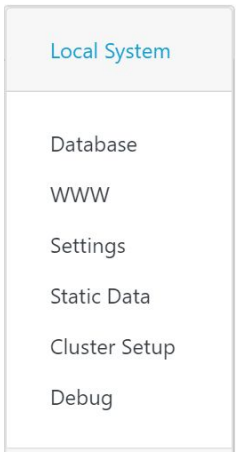
Cluster members need to authenticate with one another. This is done with the use of a shared secret key. Each cluster member has a list of secret keys that it uses to create JSON Web Tokens (JWTs) to send along with its HTTP requests. This way the secret key never leaves the system. The cluster member receiving the request verifies that at least one JWT is valid and then processes the request granting access to the cluster.

To create a cluster key,

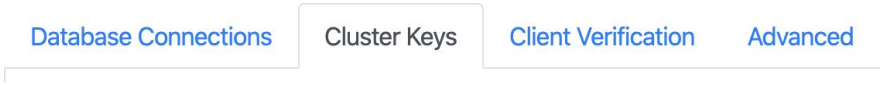
1. Click on the System Section (gear icon)



2. Choose Local System > Cluster Setup



3. Select Cluster Keys



4. New Key

5. Add a secret key and Save

Database Access Point

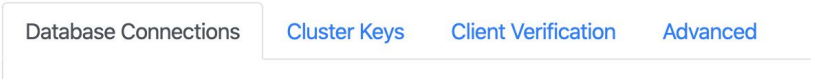
Becoming a Database Access Point is trivial. Simply have the same secret key as the member connecting to you. Database communication is bidirectional meaning that if a system connects to a Database Access Point with a valid cluster key, the Database Access Point is now part of that system's cluster. Database Access Points are NOT required to define other Database Access Points in their configuration.

Connecting to the Database Access Point

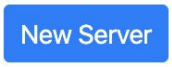
All systems that are not designated as Database Access Points need to be configured to communicate with at least one Database Access Point. For fault tolerance, multiple Database Access Point urls are typically defined. We recommend that you limit your configuration to six or fewer Database Access Point urls. After six connections, fault tolerance should be achieved, there is diminishing returns for all other urls and it wastes resources on both the endpoints.

To connect to a Database Url

1. From the Cluster Setup, choose Database Connections



2. Choose New Server



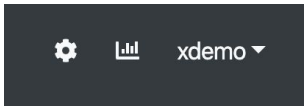
3. Enter the url of the cluster member that will be the Database Access Point
4. Optionally, you can configure the HTTPS agent of NodeJS. This is an advanced configuration and typically not needed. Contact support before changing this configuration
5. Save

Database connections take effect when the server restarts

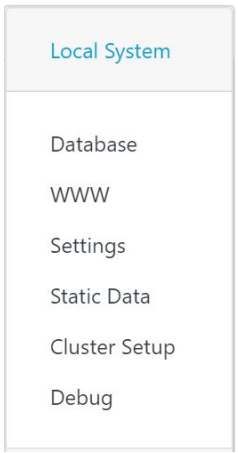
Session Servers

By default all servers are configured as session servers. No special configuration is needed to become a session server in a cluster. However, as a sanity check verify that this server is configured to launch sessions.

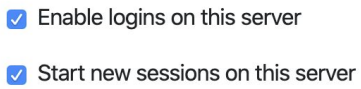
1. Click on the System Section (gear icon)



2. Choose Local System > Settings



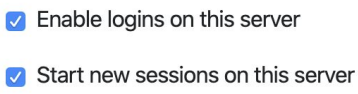
3. Verify Start new sessions on this server is checked



Login Servers

Session servers and Login servers are almost exclusively interchangeable. That it was why it was not defined as a role. There are very few use cases when you would want to configure a server that a user can log in to but not launch a session (perhaps for some authentication logging reason, or very advanced configuration). Starting a session requires a user level process running on the system which is typically launched when a user logs in. For completeness, to enable a Login server

1. Verify Enable Logins on this server is checked



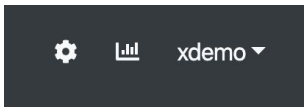
Gateway Servers

Every server in the cluster is automatically a Gateway server. A user can connect to any server, and that server will proxy the request to the proper endpoint. Conceptually however, Gateway servers are often associated with a subset which we call Gateway Proxies

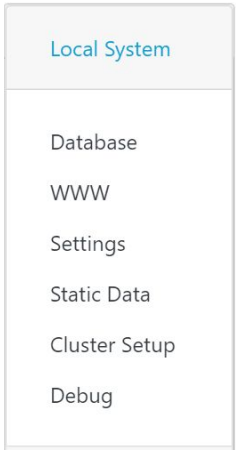
Gateway Proxies

Gateway proxies are the polar opposite of Session Servers. Users cannot log in to them and users cannot start sessions on them. Their job is to exclusively proxy data from the user to the end point. To configure a Gateway Proxy

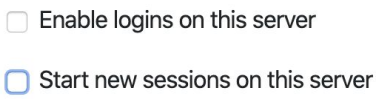
1. Click on the System Section (gear icon)



2. Choose Local System > Settings



3. Uncheck Enable Logins ... and Start new sessions ...

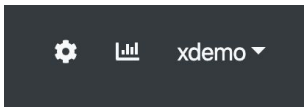


4. Save

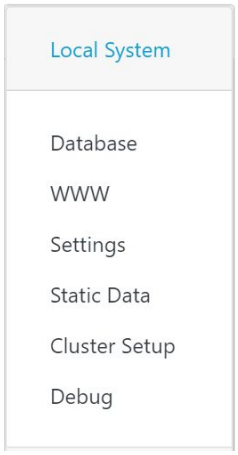
External Servers

External servers are typically located outside of a LAN and often used as a Gateway Proxy to connect to the Session servers. Since they typically cannot see any other cluster members, they MUST be a Database Access Point to at least one other cluster member. Otherwise it will be an isolated system. All servers marked as external maintain an HTTP Server Sent Event connection from EVERY member in the cluster for message passing purposes. To configure a server as external.

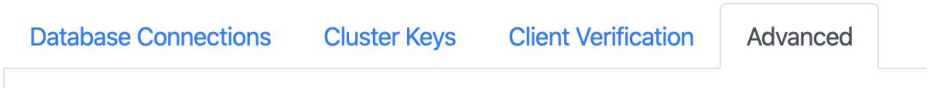
1. Click on the System Section (gear icon)



2. Choose Local System > Cluster Setup



3. Choose Advanced



4. Check Server is External

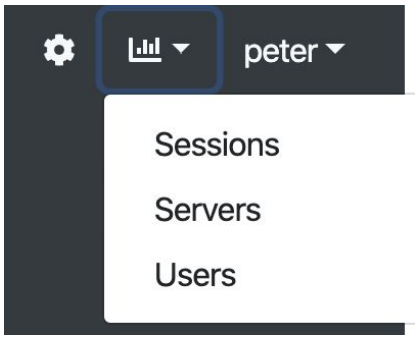
5. Save

Monitoring Cluster Members

Verifying the Cluster is Working

Once the server is set up, it is a good time to make sure the cluster members are communicating properly. As an administrator the easiest way is to check the Manage Section of the website

1. Click on the Manage Section (Graph Icon) > Select Servers

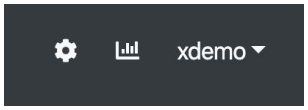


Every server in the shared database that has been recently updated will be listed

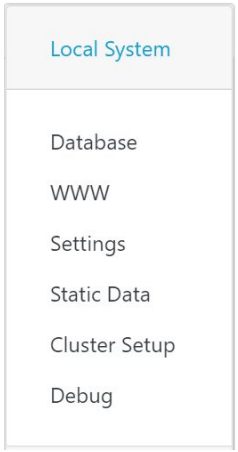
If you do not see your server listed after about 90 seconds something has probably gone wrong and it would be good to check that specific system. You may also want to enable Debug logging on both systems in the cluster to log any issues. Debug logging prints a lot of information and should be turned off when not absolutely necessary.

To enable Debug Logging

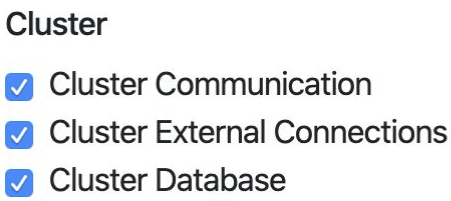
1. Click on the System Section (gear icon)



2. Choose Local System > Debug



3. Check the Clustering Debug Options



4. Save
5. To view the log run the command in a terminal: /usr/lib/fast/3/tools/web-log
    a. This command is a shortcut to: journalctl -u fastx3.service -f

Cluster Member Data

Every FastX Server periodically updates the database with information about the state of the server. Lots of information is given including number of sessions, users logged in, CPU Load Average, free memory and many others. This data is helpful in defining monitoring and grouping similar servers together. Cluster member data is most often used in Load Balancing to decide which server to connect to.

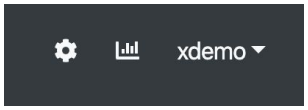
Static Data and Metrics perform the same function in very different ways: namely to provide custom data to the server object. Static Data is used most often as typically the necessary information does not change from one update to the next. Metrics are used for transient data that is not already provided by the server update

Static Data

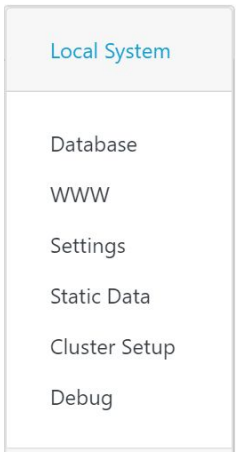
Administrators who wish to add custom data to their cluster members should use the static data object. Static data is a JSON Object that gets sent with every server update request and is

useful in defining the features of a server. Administrators who wish to subdivide servers into smaller sub-clusters should use static data.

1. Click on the System Section (gear icon)



2. Choose Local System > Static Data



3. Edit the static data JSON object with the data you wish to send and save

Use Cases

Below are some typical use cases of when you would use Static Data. Remember that Static Data only adds information to the server update. This information will be used later in load balancing scripts.

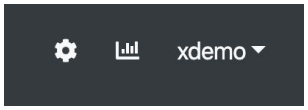
- Some of your servers have a GPU -- add "gpu":true
- Only allow certain users access to the system -- "users": ["user1", "user2" ..., "userN"]
- Create server Groups -- "group": "mygroupname"
- Define login nodes -- "login": true

There are numerous examples of how administrators use static data. Use Static Data to fine tune your Load Balancing scripts

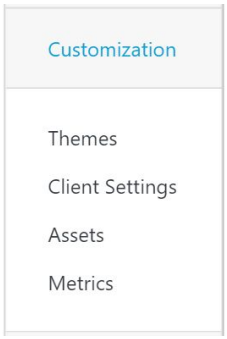
Metrics

Static data sends the same data along with every update and are unique to each server. Metrics on the other hand are Javascript functions that are calculated on each server update to create a JSON value (Number, Boolean, Object etc) to send with the updates. Metrics should be used when you have a custom parameter that will change over time.

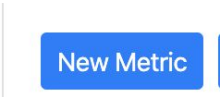
1. Click on the System Section (gear icon)



2. Choose Customization > Metrics



3. Choose New Metric



4. Create a Javascript function that returns a JSON value

Metrics will be sent along with the database update. The name of each metric is a parameter of the metrics object with the result of the function as its value.

Use Cases

Static Data is the most commonly used form of custom data. Metrics are typically used to access a third party application (or even the linux system) to calculate a value. Common Use cases include

- Find the number of licenses in use of a specific application
- Find the number of memory intensive processes running

Logging in and Starting Sessions

Now that you have defined and set up your cluster, added your and things are up and running, it is time to move to the next step which is actually getting your users to the session servers so

they can start sessions. The two main methods to do this are Load Balancing and Job Scheduling.

Load Balancing is a set of Javascript functions that are executed by the web server with the goal of finding a serverId to run the API call. Load Balancing can be used for both Logging in and Starting sessions

Job Scheduling is only used for Starting sessions. Job Scheduling takes the start parameters given by the user and tries to create a template command that will be executed as the user on the system. Technically the template can execute any command on the system, not just the start command. This feature is called Job Scheduling because the use case for it is to use a third party job scheduler to run the session start script some time in the future.

Load Balancing and Job Scheduling can be used together. The Load Balancing script selects ServerA to send the information to and the Job Scheduler creates a template that will be executed on ServerA.

Notes on Login Types

A full discussion of authentication is out of the scope of this document. However, logins can break down into roughly two types. Link Daemons and Non Link Daemons. Link daemons are logins which contain the claim "fastx/daemon" in their properties.

The purpose of a Link Daemon is to start sessions for logins that do not have an associated process running (Web Logins, OpenID Connect etc). When a user tries to launch a session on a cluster member that is not the one he logged in to, the start session attempts to authenticate via SSH to launch a Link Daemon. The Link Daemon is then available for future start sessions so a double authentication is only periodically needed.

Administrators can avoid double authentication by granting sudo access to the fastx user to launch the link command.

Load Balancing

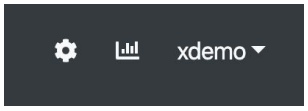
The goal of load balancing is simple: select which server a session will be started on. Running sessions have a well defined server (the one where the process is running). A user's login has a well defined server (the one who generated the login token). Configuration is always either local (the server the admin connected to) or global (synced across a cluster for all servers). The only time the server is not defined is at the start operation.

Every organization has different requirements for how to select a server either for starting sessions. Load balancing is defined by a custom javascript function that the administrator

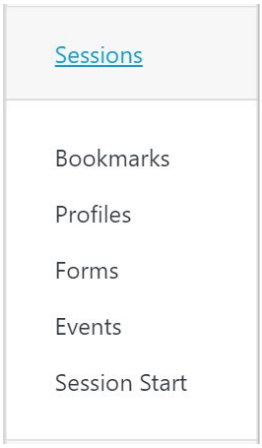
writes (or gets help from support!) to choose the server. Multiple javascript functions can be defined and chained together to sort, filter, and ultimately select the server to connect to.

**NOTE: Administrators can also choose to load balance SSH Logins. Documentation on Load Balancing SSH Logins.

1. Click on the System Section (gear icon)



2. Choose Sessions > Session Start



3. Multiple Predefined scripts are shipped with FastX, or an administrator can create his own script by clicking New Script

4. To Set your scripts, click on the Actions Icon and set the script

5. Then choose the order of the scripts you want executed and submit

The Server List.

The Load Balancer takes an array of servers and passes it to the load balancing function to select from. Depending on your setup, servers may be filtered out before ever executing this function.

- Servers with Enable logins... unchecked will be filtered out of the login script

- Servers with Enable Server Reservations (in Cluster > Cluster Setup > Advanced) checked and with non Link Daemon logins on the system (ie user login) will be filtered out of the login script

- Servers with Start sessions... unchecked will be filtered out of the start script

Creating Custom Load Balancing Scripts

The default load balancing scripts that ship with FastX are often all you need to properly connect to your systems. Advanced administrators may want to create their own custom scripts to fine tune the way the cluster chooses which server connects to. In this case administrators should create custom load balancing scripts to pick the server. Load Balancing scripts can get complex. We typically recommend reaching out to StarNet Support before attempting to write your custom scripts as this can help ease the development of the scripts

The Load Balancing Function

The load balancing function is a Javascript function that takes an input object and returns a serverId (or other value, see below). Below is a basic example that returns the serverId of the system that the user connected to.

```
function(input) {
  return input.local.serverId;
}
```

The Input Object

The input object is a JSON object that is sent to the load balancing function from the web server. It contains the following parameters

```
{
 "action": "STRING", //the action that will be executed,  "user/login" ||
"session/start"
  "user": user_data, //the user data object
  "userGroups": ["g1", "g2", "gN"], /* User's Linux User Groups */
  "isManager": false, /* Is this user a manager */
  "isAdmin": false, /* Is this user an admin */
  "local": { //local server object
    "serverId": "STRING", //the serverId of the system executing the
function
  },
  "servers": [ server_object1, server_object2, ..., server_objectN],
  //array of server objects
  "data": data_object, //the data passed from the user in the API request

}
```

User_Data

The user_data object is a JSON object that contains the information of the user making the request. The user_data object is different depending whether the script being run is a login script or a start script.

Login Script

The login script is run before a user authenticates. Therefore there is limited data available for the load balancer to use.

```
{
```

```
        login:"STRING", //the username that was passed during the
authentication
        serverId:"STRING", //the serverId that was passed by the user
during authentication (could be empty)
        sessions: [session1, session2, ... sessionN] //the sessions
associated with the login name
}
```

Start Script

The user_object for the start script contains all the parameters in the login scripts user_object ("login", "serverId", "sessions") as well as the login information available.

Server_Object

The server object is the data passed from each server during a server update. See Server Api

Session_Objects

See Session Object Api

The Return Value

The load balancing function can return several values.

String

If the function returns a string, return value will be used as the serverId to connect to. Make sure this is an actual serverId that exists in the cluster (ie. don't just return any string)

Array

If the function returns an array, this new array will be used as the new set of server objects that will be passed to the next load balancing function. This return value can be used to filter out specific servers.

Falsy Value

If the function returns something that evaluates to false (undefined, null, 0, "", etc), the load balancer will move on to the next function in the list using the previous input object.

Errors

Any errors that occur will stop the load balancing scripts from running and return the error object to the user to display. You can use this to throw custom error messages, for example "All GPU servers are in use"

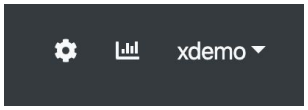
If the load balancer has run through all load balancing scripts and still has not returned a string (ie serverId), then an error will be thrown.

Server Reservations

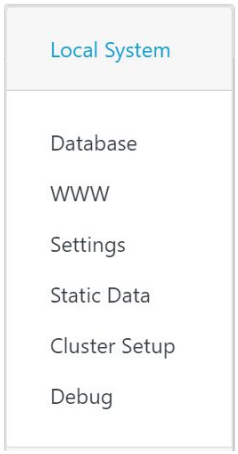
Server reservations are a feature that will add extra checks to the login process that will guarantee only one user is on the system at any given time. This allows admins to create pools of servers that their users can access as their own server. When a user logs in successfully, the server is reserved and removed from the list of available servers in the server list. All Load Balancing rules for logging in and starting sessions still apply. This means that also a user may have reserved a server, the administrator could create a start Load Balancing script that chooses a different server altogether. This is useful if you have a group of servers that can act as general purpose servers for individual users, and a second group of servers that are specialized (e.g. servers reserved for GPU applications)

To enable Server Reservations

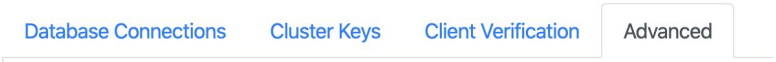
1. Click on the System Section (gear icon)



2. Choose Local System > Cluster Setup



3. Select Advanced



4. Check Enable Server Reservations

5. Save

The Server Reservation Algorithm

Server Reservations work as follows

1. The Load Balancer selects a Login Server to connect to
2. The Gateway Server adds an authentication entry into the database
3. The Gateway Server then sends the request to the Login server
4. The Login server then processes the request
    a. Authentication may take multiple requests to finally log in
5. Upon successful authentication, the Gateway server checks if the authentication entry is in the database
    a. If the entry is in the database, the login is successful. The Gateway server then clears all authentication entries in that database.
    b. If the entry is not in the database, the Gateway server throws an error that the session is reserved.
        i. The clearing of the authentication entries avoids a race condition where two users could begin authenticating at the same time and receive the same server from the Load Balancer. The first user to successfully authenticate reserves the server
6. A server is considered reserved if it has Server Reservations enabled and there is at least one login that is not a Link Daemon. Reserved servers are filtered out of the server input object
7. Logging out (putting the login count to 0) will free up the server so it can be reserved again

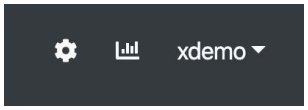
Job Scheduling

Up to this point we have focused our discussion on choosing the server to log in to and choosing the server to start new sessions on. When starting a session, what happens when the server you want to pick is not yet available? This is where job scheduling comes in. Job scheduling allows an admin to replace the session start command with a different command and pass the user's start parameters to this new command.

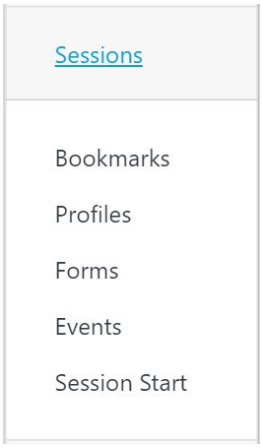
The replacing of the start command allows administrators to integrate their own Job Schedulers into FastX. Instead of launching a new session, FastX returns text that can be displayed to the user. When the session is eventually started, the session will appear in the session list. Sessions can start immediately, after a short time, or not at all.

To get to the Job Scheduling section

1. Click on the System Section (gear icon)



2. Choose Sessions > Session Start



3. Select the Schedule tab

The Job Scheduling Function

The Job Scheduling function is a Javascript function whose job is to decide whether to execute a shell command in place of the start script or to start a session in the traditional way. When a string is returned by the Job Scheduling function, the string is parsed and the parameters from the input data are interpolated.

The Input Object

The Job Scheduling function takes a JSON input object that the Job Scheduler can use to make decisions about how the session will be launched

```
{
    "user": login_object, //The user's login object,
    "admin": true, //Is the user an administrator,
    "start": start_data, //The data that was passed from the user to the
start API call"
}
```

Login Object
See User Logins

Start Object
[Ses API Start]

The Return Value

The Job Scheduling function can return either a string or a falsy value

Fasly Value

If the Job Scheduling function returns something that evaluates to false, FastX will start the session as usual, and the session will immediately launch.

String

Returning a string will enable Job Scheduling and execute the interpolated template. Any output from the command will be displayed to the user

Errors

Any errors that occur will stop the Job Scheduler from running and return the error to the user. You can use this to throw custom error messages like "Job Scheduling is Disabled".

A Job Scheduling Example

Here is an example of a Job Scheduling function

```
function(input) {
  return "bsub \
      /usr/lib/fastx/3/scripts/start \
      --command ${ start.command } --name ${ start.name } \
      > /dev/null; \
      echo Your Job Has Been Scheduled"
}
```

The function returns a string template. This string template is merged with the data passed during the API start call to create a new string that will be executed by the user's Link process. The string that is returned is quite complex so it is worth it to break it down into its component parts, line by line.

bsub

The first part of the string is bsub. Bsub is the command to submit a job to the LSF job scheduler. bsub is only an example. FastX works with any Job Scheduling tool. The main pont here is that the command that will be executed by the Link process is bsub, not the start command.

/usr/lib/fastx/3/scripts/start

This is the actual start script that launches the session. When Job Scheduling is not enabled, the user's Link process runs this command directly and returns the result. At some point in the command execution, this script should be called

--command ${ start.command } --name ${ start.name }

These are the parameters that are passed to the start script. In our example we are passing two parameters, command (which is the command that start will run -- required) and name (which is the display name of the session)

Notice the strange string ${ start.command }. This is a template variable. start is the API parameter object that the user passed to the start API call. For example, if the user tried to start a session with the parameters

```
{
  "command": "xterm -ls",
   "name": "My Shiny Xterm"
}
```

the string would evaluate to
--command "xterm -ls" --name "My Shiny Xterm"

> /dev/null;

This line is just standard shell stuff redirecting stdout to /dev/null (throwing it away). Note the semicolon at the end. This lets us execute another command after this first one completes

echo "Your Job Has Been Scheduled"

We are again doing standard shell stuff; in this case echoing a line. Any output (stdout, stderr, or system) will be saved and shown to the user. Since there is no indication that the Job will ever start, we show output to the user to at least let them understand that the job was submitted.

Conclusion

FastX's clustering capabilities are fairly complex and very flexible to be able to fit your organization's needs. Administrators can choose to use parts or all of the features to build clusters that will integrate into the organization's existing infrastructure. Load Balancing and Job Scheduling allow administrators to redirect workload across the cluster in a way that will help them maximize the ROI in their computing devices.

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