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Observing Node Performance with DTrace

Topic Outline

- **Introduction**
  - What is DTrace?
  - How DTrace can be used with node.js
- **DTrace kernel actions**
- **DTrace the node engine**
- **DTrace node applications**

What is DTrace?

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- **Tool that allows one to dynamically instrument code from application level and into the kernel.**
- **Can be used safely on production systems.**
- **Uses:**
  - Performance Analysis
  - Debugging
  - Code coverage
  - Find out wtf is happening in your software
- **Available on illumos, smartOS, and other Solaris 10 derivatives, as well as *BSD and Mac OS X.**

Terminology

- **System Call - Request for an action by the Operating System**
- **Probe - An instrumentation point in the code**
  - Dynamic and Static probes are provided, and new ones can be added
  - A probe is specified by a 4-tuple:
    - provider:module:function:probename{action}
- **Action - Executed when a probe fires**
- **Predicate - Optional boolean to determine whether or not to execute the action**
- **Example:** `syscall::read:entry/pid == 713/{trace();}`

Node.js with DTrace Support

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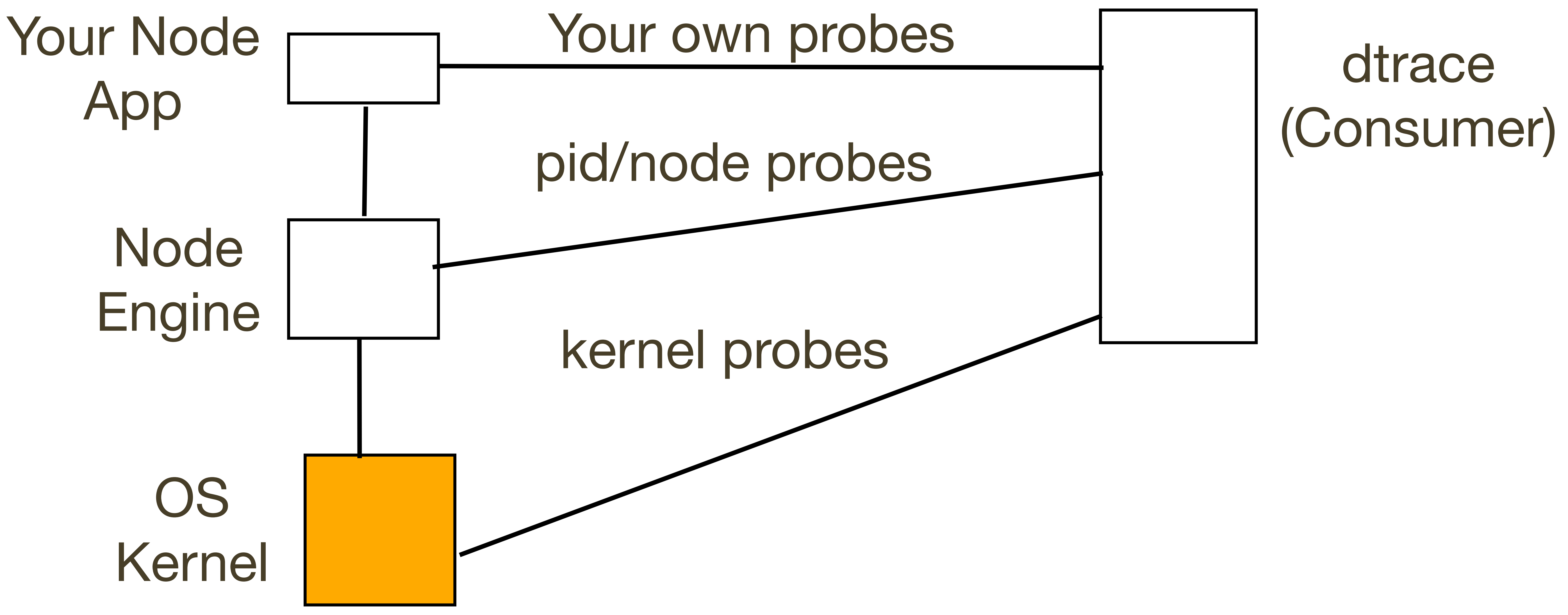
- **From www.nodejs.org download site**

```
# curl -O http://nodejs.org/dist/v0.8.11/node-v0.8.11.tar.gz
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100 11.2M  100 11.2M    0     0   253k      0  0:00:45  0:00:45 --:--:--  349k
# gtar -xpf node-v0.8.11.tar.gz
# pkgin install gcc-compiler-4.6.1
...
# cd node-v0.8.11
# ./configure
...
# make
...
# make install   <-installs in /usr/local/bin
...
# export PATH=/usr/local/bin:$PATH
# node -v
v0.8.11
# cd ..
# npm install dtrace-provider
...
# npm install restify  <- This is not necessary, but will be used in some of the demos
...
```

Architecture



- **With DTrace, you can trace events in**
  - The node Engine
  - Node.js scripts
  - The kernel (system calls, scheduling, memory management, etc.)

Some Simple Examples

- Show system calls made by a running node process

```
# dtrace -n ‘syscall:::entry/pid==26442/{}’
dtrace: description 'syscall:::entry' matched 234 probes
CPU     ID                    FUNCTION:NAME
  1  10157                     write:entry
  1  10283                  lwp_park:entry
  1  10155                      read:entry
  4  10155                      read:entry
  4  10157                     write:entry
...
```

- Count system calls made by a running node process

```
# dtrace -n 'syscall:::entry/execname == "node"/{@[probefunc]=count();}'
dtrace: description 'syscall:::entry' matched 234 probes
(^C)
...
 munmap                                                   31
 portfs                                                   36
 lwp_park                                                 37
 fcntl                                                    39
 mmap64                                                   53
#
```

An Example Measuring System Call Latency

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- systime.d

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

syscall:::entry
/execname == "node"/
{
     self->ts = timestamp;
}

syscall:::return
/self->ts/
{
     @[probefunc] = quantize(timestamp - self->ts);
     self->ts = 0;
}

END
{
     printa("SYSCALL    NSECS                                    # OF OCCURANCES\n%s%@lx\n", @);
}
```

An Example Measuring System Call Latency (Continued)

```
# ./systime.d
...
SYSCALL     NSECS                                     # OF OCCURANCES
  read
            value  ------------- Distribution ------------- count
             1024 |                                         0
             2048 |@@@@@@@@@@@@@                            3
             4096 |@@@@@@@@@                                2
             8192 |@@@@@@@@@                                2
            16384 |@@@@                                     1
            32768 |                                         0
            65536 |                                         0
           131072 |                                         0
           262144 |                                         0
           524288 |                                         0
          1048576 |                                         0
          2097152 |                                         0
          4194304 |                                         0
          8388608 |                                         0
         16777216 |                                         0
         33554432 |                                         0
         67108864 |                                         0
        134217728 |@@@@                                     1
        268435456 |                                         0

 ...
```

Architecture

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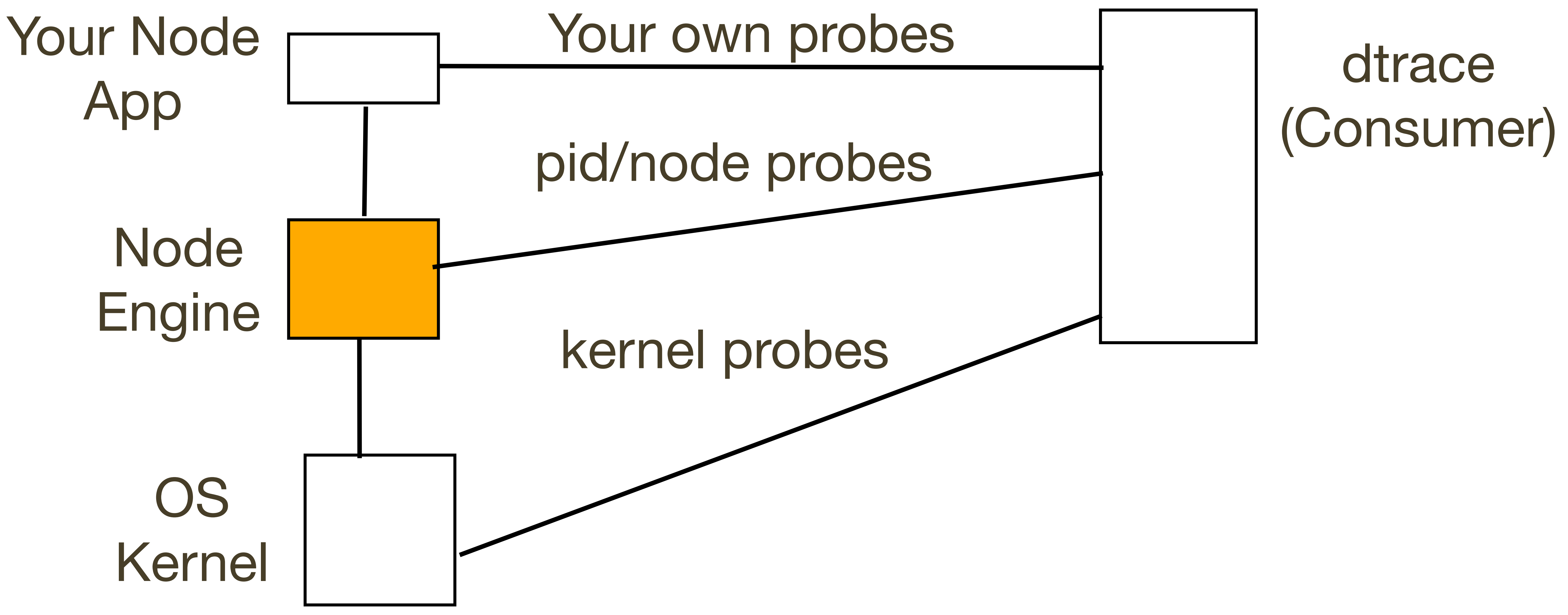

- **With DTrace, you can trace events in**
  - The node Engine
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  - The kernel (system calls, scheduling, memory management, etc.)

The Node DTrace Provider

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- Set of USDT probes built into node

```
# dtrace -l -n 'node*:::{}'
   ID   PROVIDER            MODULE                          FUNCTION NAME
57166  node11665             node
_ZN4nodeL14dtrace_gc_doneEN2v86GCTypeENS0_15GCCallbackFlagsE gc-done
57167  node11665             node
_ZN4nodeL15dtrace_gc_startEN2v86GCTypeENS0_15GCCallbackFlagsE gc-start
57168  node11665             node _ZN4node26DTRACE_HTTP_CLIENT_REQUESTERKN2v89ArgumentsE
http-client-request
57169  node11665             node _ZN4node27DTRACE_HTTP_CLIENT_RESPONSEERKN2v89ArgumentsE
http-client-response
57170  node11665             node _ZN4node26DTRACE_HTTP_SERVER_REQUESTERKN2v89ArgumentsE
http-server-request
57171  node11665             node _ZN4node27DTRACE_HTTP_SERVER_RESPONSEERKN2v89ArgumentsE
http-server-response
57172  node11665             node _ZN4node28DTRACE_NET_SERVER_CONNECTIONERKN2v89ArgumentsE
net-server-connection
57173  node11665             node _ZN4node22DTRACE_NET_SOCKET_READERKN2v89ArgumentsE net-
socket-read
57174  node11665             node _ZN4node23DTRACE_NET_SOCKET_WRITEERKN2v89ArgumentsE net-
socket-write
57175  node11665             node _ZN4node21DTRACE_NET_STREAM_ENDERKN2v89ArgumentsE net-
stream-end
```

The Node DTrace Provider
Probe Arguments

```
# dtrace -l -v -n 'node*:::http-server-request, node*:::http-server-response{}'
   ID   PROVIDER            MODULE                          FUNCTION NAME
57170  node11665              node _ZN4node26DTRACE_HTTP_SERVER_REQUESTERKN2v89ArgumentsE
http-server-request

  Probe Description Attributes
            Identifier Names: Private
               Data Semantics:   Private
               Dependency Class: Unknown

       Argument Attributes
             Identifier Names: Evolving
              Data Semantics:   Evolving
              Dependency Class: ISA

   Argument Types
          args[0]: node_http_request_t *
          args[1]: node_connection_t *

57171  node11665              node _ZN4node27DTRACE_HTTP_SERVER_RESPONSEERKN2v89ArgumentsE
http-server-response

 ...
          args[0]: node_connection_t *
```

The Node DTrace Provider Probe Arguments (Continued)

- In `node-v0.8.11/src/node.d`

```
typedef struct {
    string url;
    string method;
    string forwardedFor;
} node_http_request_t;

typedef struct {
    int fd;
    string remoteAddress;
    int remotePort;
    int bufferSize;
} node_connection_t;
```

The Node DTrace Provider: Example 1

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```
/* echo-server.d */

#pragma D option quiet

BEGIN
{
     printf("%-22s %-20s %-8s %-16s %-16s %-16s\n",
       "DIRECTION", "URL", "METHOD", "REMOTEADDRESS", "REMOTEPORT", "BUFFERSIZE");
}

node*:::http-server-request
{
     printf("%-22s %-20s %-8s %-16s %-16d %-16d\n",
       probename, args[0]->url, args[0]->method, args[1]->remoteAddress,
       args[1]->remotePort, args[1]->bufferSize);
}

node*:::http-server-response
{
     printf("%-22s %-20s %-8s %-16s %-16d %-16d\n",
       probename, " ", " ", args[0]->remoteAddress,
       args[0]->remotePort, args[0]->bufferSize);
}
```

The Node DTrace Provider: Example 1 (Continued)

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- **Client**

```
# curl http://165.225.154.78:8080/echofile-server.js > /dev/null
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100  1377  100  1377    0     0   382k      0 --:--:-- --:--:-- --:--:--  672k
```

- **Server**

```
# dtrace -L /usr/local/lib/dtrace -s echo-server.d
DIRECTION                URL                    METHOD   REMOTEADDRESS    REMOTEPORT
BUFFERSIZE
http-server-request      /echofile-server.js   GET      62.203.55.164    58027           0
http-server-response                                    62.203.55.164    58027           0
http-server-response                                    62.203.55.164    58030           0
http-server-request      /echofile-server.js   GET      62.203.55.164    58030           0
http-server-request      /echofile-server.js   GET      62.203.55.164    58036           0
http-server-response                                    62.203.55.164    58036           0
http-server-request      /echofile-server.js   GET      62.203.55.164    58037           0
http-server-response                                    62.203.55.164    58037           0
http-server-request      /echofile-server.js   GET      62.203.55.164    58038           0
http-server-response                                    62.203.55.164    58038           0
http-server-request      /systime.d            GET      62.203.55.164    58363           0
http-server-response                                    62.203.55.164    58363           0
http-server-request      /favicon.ico          GET      62.203.55.164    58364           0
http-server-response                                    62.203.55.164    58364           0
...
```

Request/Response Latency

```
/* server-latency.d */

#pragma D option quiet

node*:::http-server-request
{
     ts[args[1]->remoteAddress, args[1]->remotePort] = timestamp;
     url[ts[args[1]->remoteAddress, args[1]->remotePort]] = args[0]->url;
}

node*:::http-server-response
/ts[args[0]->remoteAddress, args[0]->remotePort]/
{
     this->t = ts[args[0]->remoteAddress, args[0]->remotePort];
     @[url[this->t], args[0]->remoteAddress] = quantize((timestamp-this->t)/1000);
     ts[args[0]->remoteAddress, args[0]->remotePort] = 0;
}

END
{
     printf("%-20s: %-16s\n", "URL", "REMOTEADDRESS");
     printa("%-20s: %-16s\nMICROSECONDS\n%@d\n", @);
}
```

Request/Response Latency (Continued)

```
# dtrace -L /usr/local/lib/dtrace -s server-latency.d

URL                    : REMOTEADDRESS
/tmp/words             : 165.225.154.77
MICROSECONDS

           value  ------------- Distribution ------------- count
            1024 |                                         0
            2048 |@@@@                                     11
            4096 |@@@@@@@@@@@@@@@@@                        43
            8192 |@@@@@@                                   14
           16384 |@@@@@@@@@@@@                             31
           32768 |                                         1
           65536 |                                         0

/tmp/words             : 83.79.36.187
MICROSECONDS

           value  ------------- Distribution ------------- count
          524288 |                                         0
         1048576 |@                                        3
         2097152 |@@                                       4
         4194304 |@@                                       4
         8388608 |@@@@                                     11
        16777216 |@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@           74
        33554432 |@@                                       4
        67108864 |                                         0
```

Heatmaps

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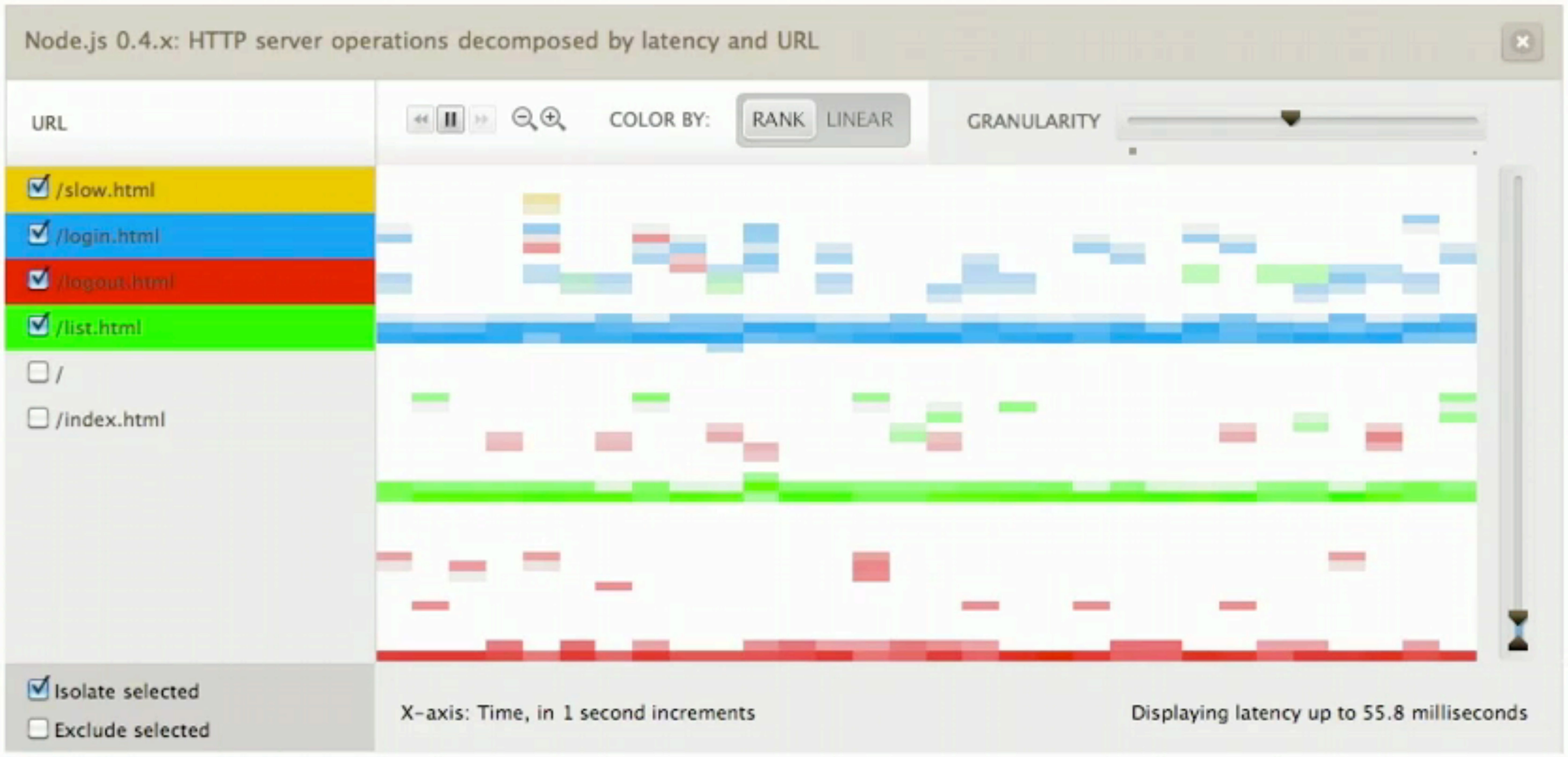


Node.js 0.4.x: HTTP server operations decomposed by latency and URL

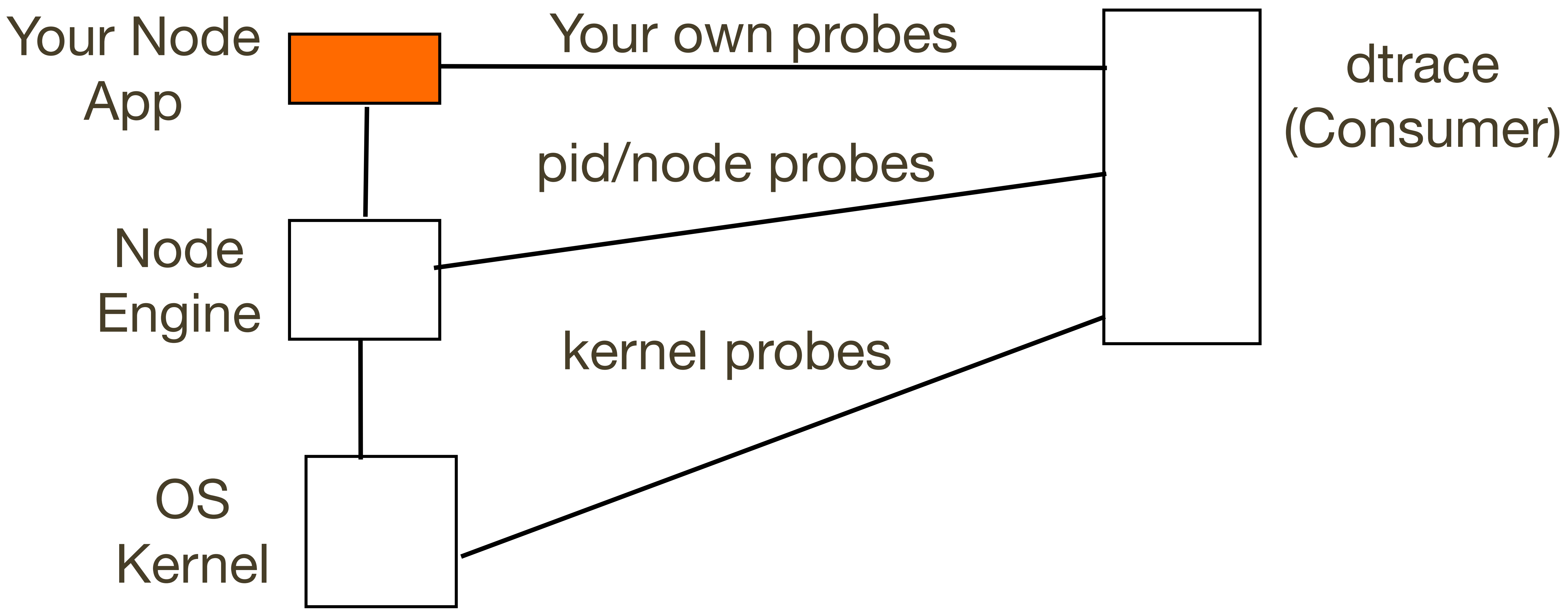
- ✓ /slow.html
- ✓ /login.html
- ✓ /logout.html
- ✓ /list.html
- ☐ /
- ☐ /index.html

✓ Isolate selected
☐ Exclude selected

X-axis: Time, in 1 second increments

Displaying latency up to 55.8 milliseconds

Architecture



- **With DTrace, you can trace events in**
    - The node Engine
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DTrace Your node.js Application

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- The dtrace-provider for Node.js allows you to create statically defined probes (USDT) in your application.
- Effectively, a way to add print statements to your scripts which only have effect when/if the probes are enabled.
- But better than print... You decide what to enable and what to print at runtime.
- Install
  - `npm install dtrace-provider`

Add Probes to Your Node App

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```
/* echofile-server.js */
...
var dtp = require('dtrace-provider').createDTraceProvider('echofile-
server');

dtp.addProbe('echo-start', 'char *');
dtp.addProbe('echo-done', 'char *', 'int');
dtp.addProbe('echo-error', 'char *', 'char *')
...


    dtp.fire('echo-start', function() {
        return [req.params[0]];
    });
    ...
        dtp.fire('echo-error', function() {
            return [req.params[0], JSON.stringify(e)];
        });
    ...
    dtp.fire('echo-done', function() {
        return [req.params[0], len];
    });
...
```

- **Define probes and arguments**
- **Add probes to your code**

DTrace The Added Probes

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- Use dtrace to enable the probes you've added

```
#!/usr/sbin/dtrace -s

#pragma D option quiet

echofile-server*:::echo-start
{
    printf("%s: %s\n", probename, copyinstr(arg0));
}

echofile-server*:::echo-done
{
    printf("%s: %s %d bytes\n", probename, copyinstr(arg0), arg1);
}

echofile-server*:::echo-error
{
    printf("%s\n", copyinstr(arg1));
}
```

Enabling the Added Probes

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```
# ./echofile-server.d
echo-start: tmp/bigwords
echo-done: tmp/bigwords 20667400 bytes
echo-start: tmp
echo-done: tmp 116 bytes
{"errno":28,"code":"EISDIR"}
echo-start: blah
{"errno":34,"code":"ENOENT","path":"blah"}
...
```

List Probes Built-in for Restify

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```
# dtrace -l -P 'myapp*'
   ID   PROVIDER            MODULE                          FUNCTION NAME
57309 myapp13446            module                              func get100-start
57310 myapp13446            module                              func get100-done
57311 myapp13446            module                              func get100-
parseAccept-start
57312 myapp13446            module                              func get100-
parseAccept-done
57313 myapp13446            module                              func get100-
parseQueryString-start
57314 myapp13446            module                              func get100-
parseQueryString-done
57315 myapp13446            module                              func get100-parseBody-
start
57316 myapp13446            module                              func get100-parseBody-
done
57317 myapp13446            module                              func get100-sget-start
57318 myapp13446            module                              func get100-sget-done
```

References

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- https://github.com/mcavage/node-restify
- http://mcavage.github.com/presentations/dtrace_conf_2012-04-03/
- https://github.com/chrisa/node-dtrace-provider
- http://dtrace.org/blogs/blog/category/node-js/
- http://dtrace.org/blogs/dap/files/2012/05/fluent.pdf
- http://dtrace.org/blogs/bmc/2010/08/30/dtrace-node-js-and-the-robinson-projection/
- http://dtrace.org/blogs/dap/2012/01/05/where-does-your-node-program-spend-its-time/
- http://dtrace.org/blogs/brendan/2011/09/26/

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- Thanks for listening!
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