Introduction to "ivy"

Block storage synthetic workload generator with real time dynamic feedback control

Hitachi Data Systems

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Why ivy?

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- Reduce cost
- Speed time to market
- Improve quality
- Simplify test setup
- Measure IOPS at a specified response time (dynamic feedback control)
- Get trust in measurement results through open source

ivy in one chart

Items in italics only available to authorized Hitachi internal users using command device connector and license key

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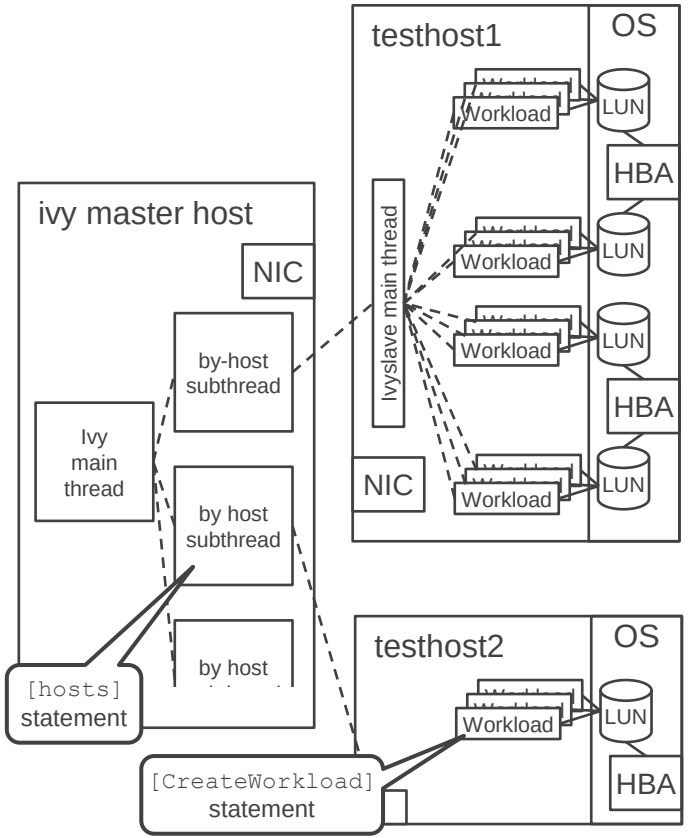
- Written in C++ using Linux native kernel Asynchronous I/O interface
  - Lowest CPU overhead – minimizes test host hardware cost & maximizes measurement accuracy
  - Designed for open source / vendor independence*, with a separately packaged Hitachi proprietary component.*
- Super easy test setup – select by LDEV, by Port, by PG, Pool ID *(by drive type with command device)*
- Can test for minimum time necessary to make a valid measurement to a specified +/- accuracy
- Real-time dynamic feedback control (DFC) enables for the first time to
  - "measure IOPS at 1 ms service time" (using DFC on rolled up host workload data – any vendor's equipment)
  - *"measure IOPS at 50% owning MP core % busy" (using DFC on filtered & rolled up command device data)*
- *Records subsystem command device performance data synchronized with host workload data*
  - *Makes validating / calibrating models easier*
- Records only valid measurement data
  - Checks number of resources reporting (ports, PGs, LDEVs, etc.) and that none running too slowly. *Checks that subsystem does not have any failed components (with command device).*
- Enables workflow automation using ivyscript programming language wrapper around ivy engine.

Scalable



- In ivy, you can layer multiple named “workload” I/O generator threads on LUNs
- Each workload thread uses an I/O sequencer plug-in that generates I/Os in scheduled I/O start time sequence.
  - We try to keep a few I/Os “pre-computed” and ready to go at all times.
  - Generalized interface allows use of any I/O pattern generator, e.g. synthetic or playback.
- Use of C++ with Linux kernel Asynchronous I/O interface means each workload thread can drive any queue depth up to limits of the OS / HBA with state of the art minimal CPU overhead.

ivy – designed for vendor independence

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1. Vendor proprietary simple SCSI Inquiry-based LUN discovery tool
   - Vendor's attribute names / values become selectable in ivy.
   - Hitachi LUN discovery tool is open source - https://github.com/Hitachi-Data-Systems/LUN_discovery

2. Ivy
   - Open source - https://github.com/Hitachi-Data-Systems/ivy
   - HDS Community site - https://community.hds.com/groups/ivy
     - (Send Ian an email to get an invitation to join, but will be public very soon.)

3. For authorized internal Hitachi users with code and license key - vendor proprietary "connector" to retrieve real time storage product configuration and/or performance data
   - Enables ivy dynamic feedback control on internal storage metrics.

ivy - open source / vendor independent

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- To support any vendor's architecture and terminology in ivy, all you need is a LUN discovery tool that makes a csv file with
  - a header line that defines vendor-specific attribute names, and
  - a data line for each LUN decoding that LUN attributes.

- Hitachi's `LUN_discovery` tool set using "`showluns.sh`" script produces something like this:

```
host,LUN name,HDS product,port,LDEV,PG,CLPR, …
testy1,/dev/sdxy,VSP,1A,00:00,1-1,CLPR0, …
testy2,/dev/sdyz,VSP,2A,00:01,1-2,CLPR0, …
```

Functionality expands with proprietary connector

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- Vendors are encouraged to prepare their own proprietary "subsystem connector" interface tools to be used with ivy.
  - Collect subsystem configuration data to augment SCSI Inquiry attribute data
    - Select a test configuration based on attributes such as disk drive type.
  - Collect real time subsystem performance data, synchronized and aligned with test host workload data.
    - Facilitates development of modeling tools.
  - Use dynamic feedback control to find the IOPS to reach a target value for
    - subsystem MP % busy, or
    - drive % busy, or
    - cache dirty data % full, etc.

Hitachi's proprietary connector does all those things

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- Hitachi's "ivy command device connector" (ivy_cmddev) is not part of the ivy open source project and will remain proprietary for internal Hitachi R&D use.
  - "command device" based functionality is not available to the public.
- Ivy presentation material and sample demo output & videos describe Hitachi command device connector functionality so as to
  - Show what ivy was designed to do
  - Serve to illustrate the functionality that other vendors could achieve by developing their own connectors.

[hosts] statement – configuration discovery

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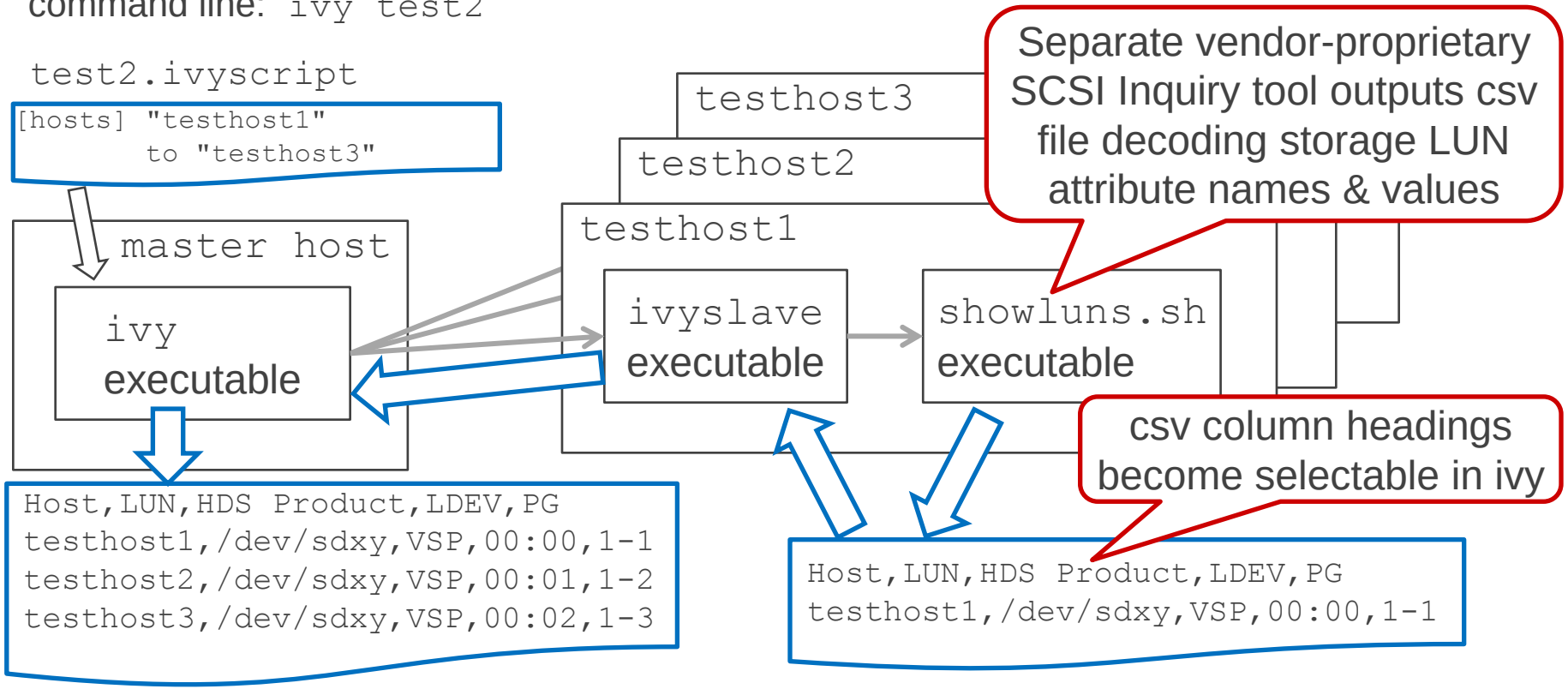
command line: `ivy test2`

test2.ivyscript

```
[hosts] "testhost1"
        to "testhost3"
```



[CreateRollup] "LDEV";

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- A rollup is what mathematicians call a "partition" – a way to divide a collection of things (in this case host-LUN-workload threads) into subgroups.
- There is by default always a rollup called "all" which has one rollup instance, also called "all" which consists of all workloads on all LUNs on all hosts.
- Otherwise, a rollup name must be combination of LUN attribute names
- If you have multiple subsystems under test, to get data rolled up by subsystem by port say

```
[CreateRollup] "serial_number+port";
```

  and get instances like "`410034+1A`".

Rollups are multi-purpose

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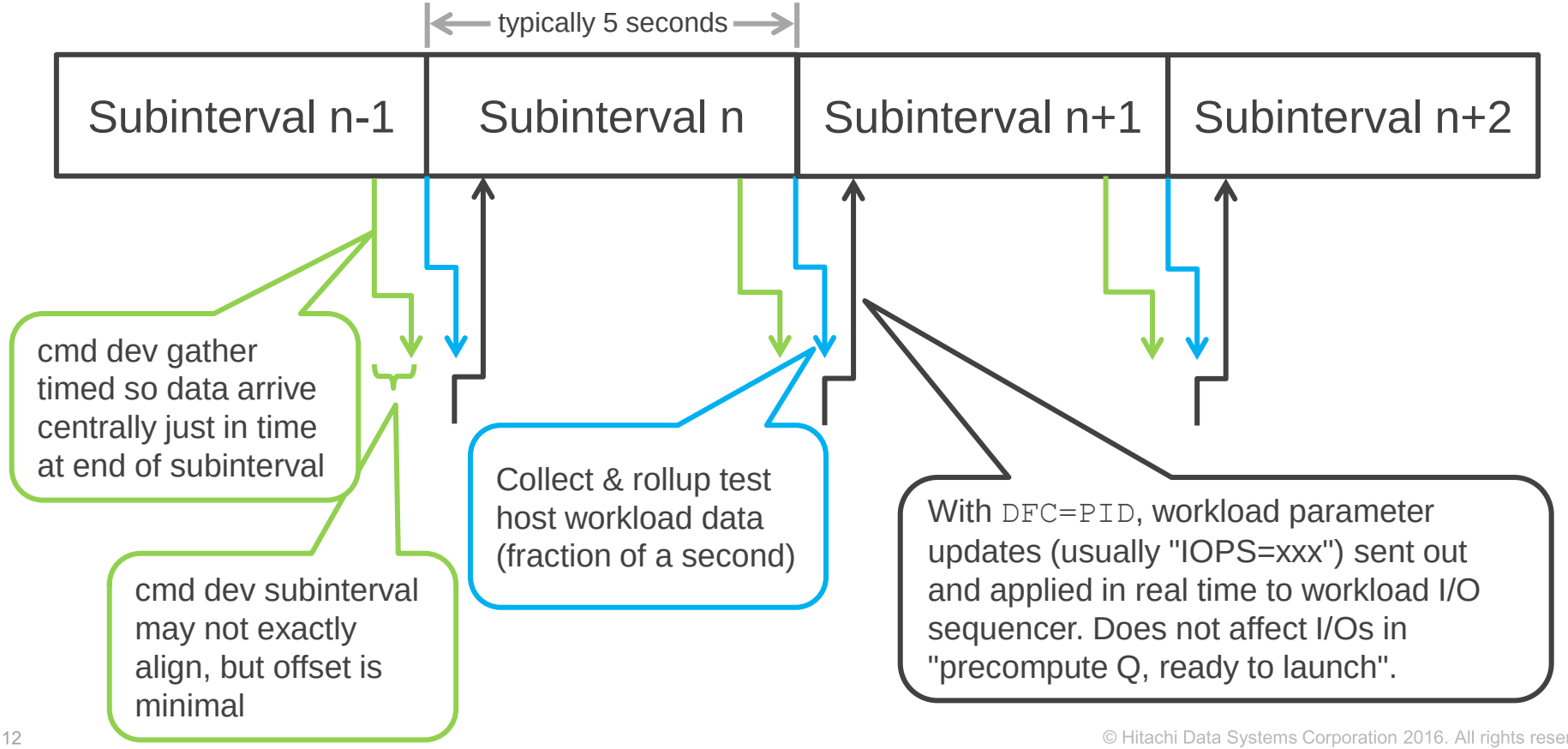
- The default is to print csv files by rollup instance.
  - Say `[nocsv]` to suppress.
- On the `[Go]` statement to run a subinterval sequence, `focus_rollup="PG"`
  - Both `dfc=pid`, the dynamic feedback control feature, as well as `measure=on`, the "seen enough and stop" `[Go]` statement feature operate at the granularity of the rollup instance.
- `[CreateRollup] "port" [quantity] 32;`
  - Will invalidate measurements if we don't get data for exactly 32 subsystem ports.
- `[CreateRollup] "port" [MaxDroop] "20%";`
  - Invalidates if there is a port whose IOPS is more than 20% slower than the fastest port.

ivy dynamic feedback control (DFC)



industry standard "PID Loop" controller

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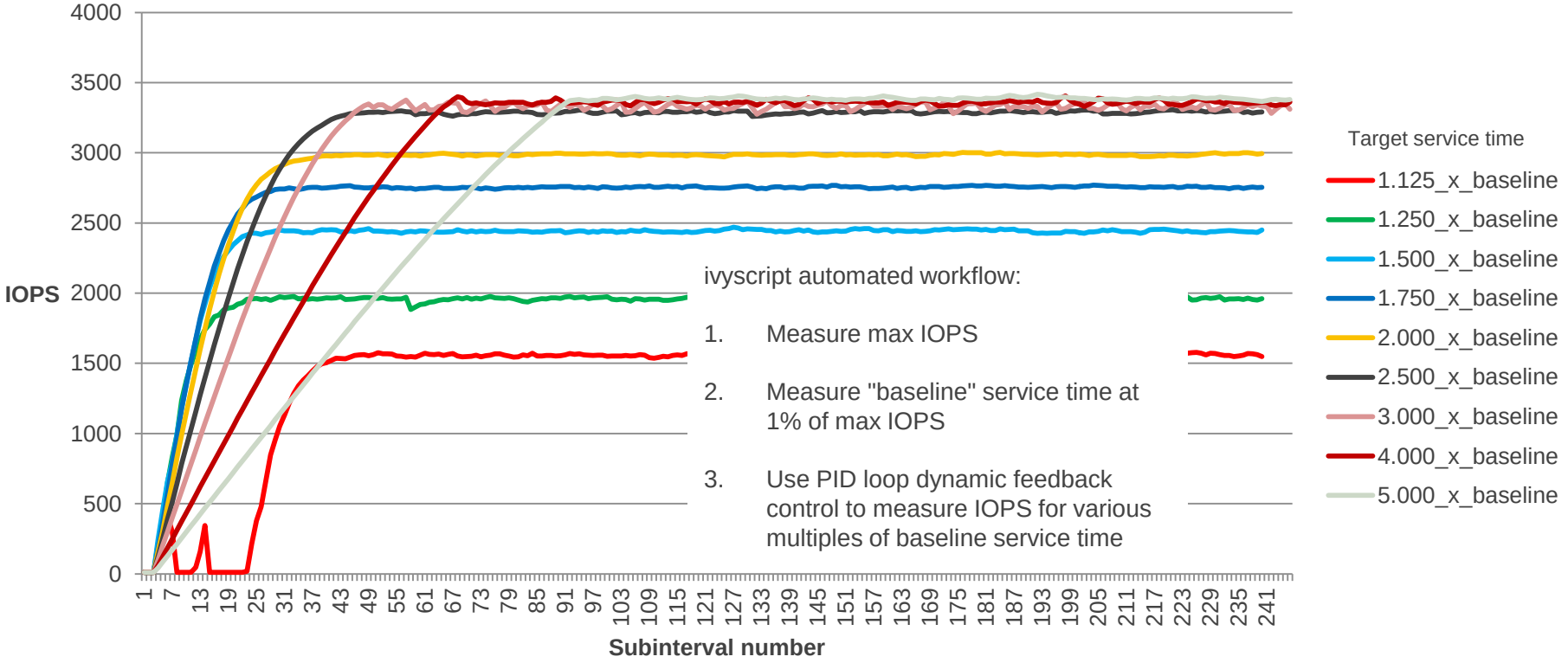

measure=on, cooldown_by_wp=on

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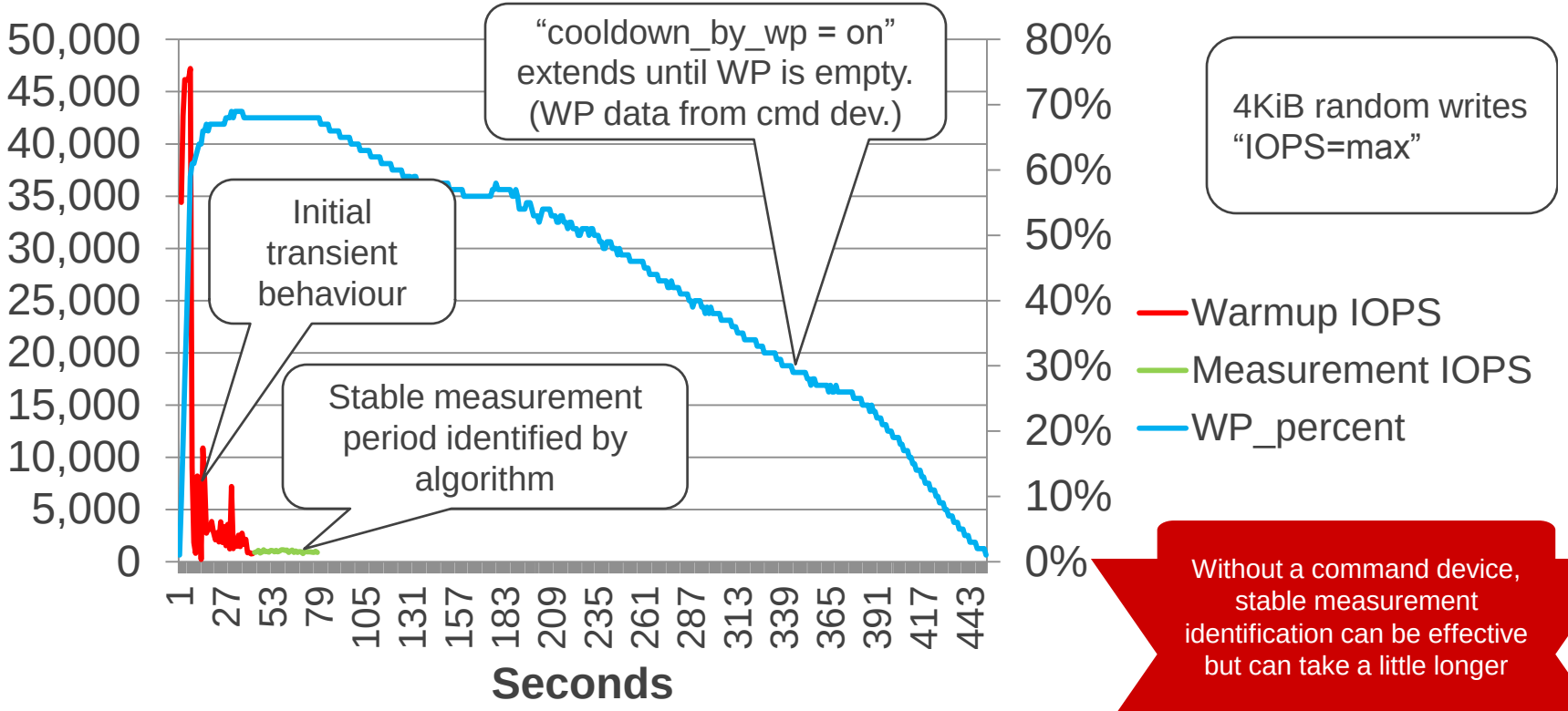

DFC on command device connector data

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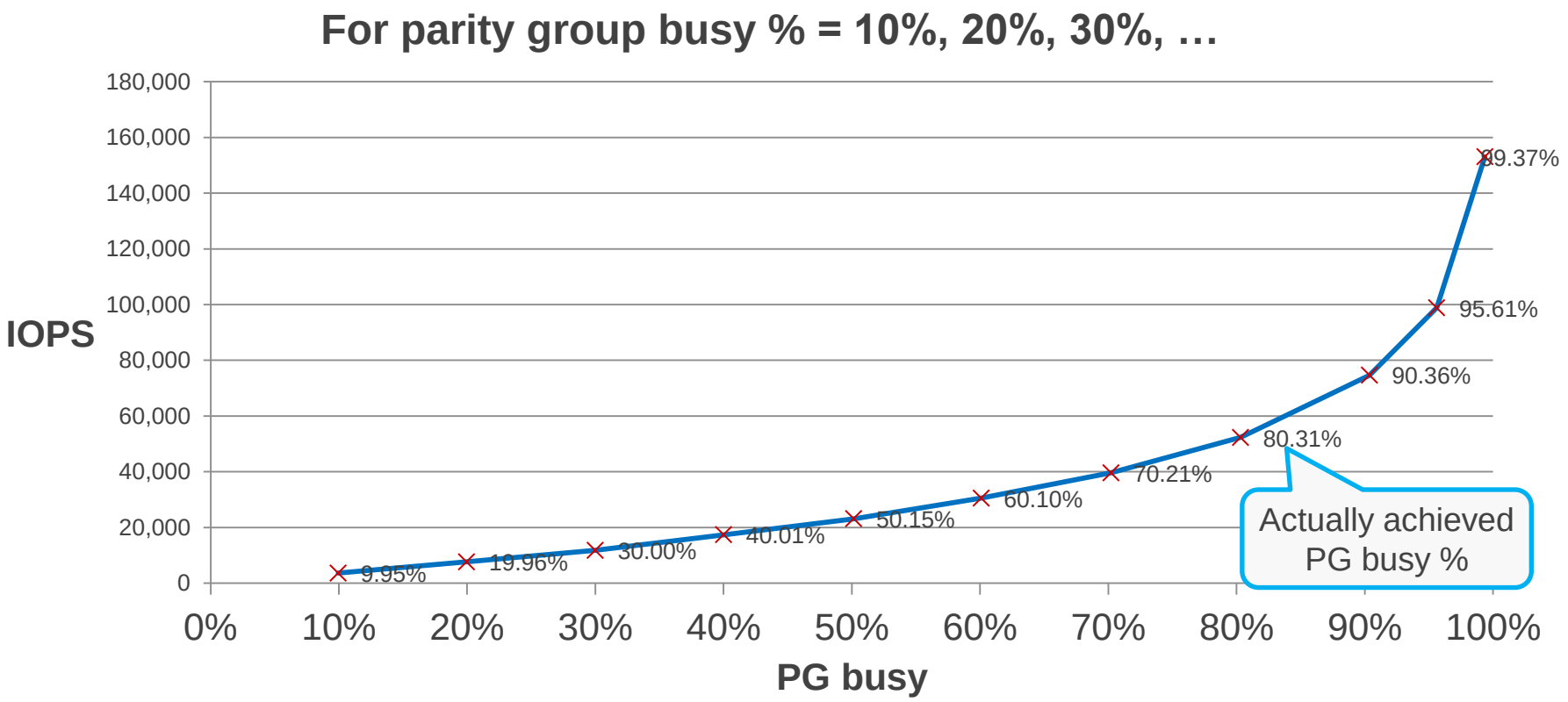

Fine-grained dynamic feedback control

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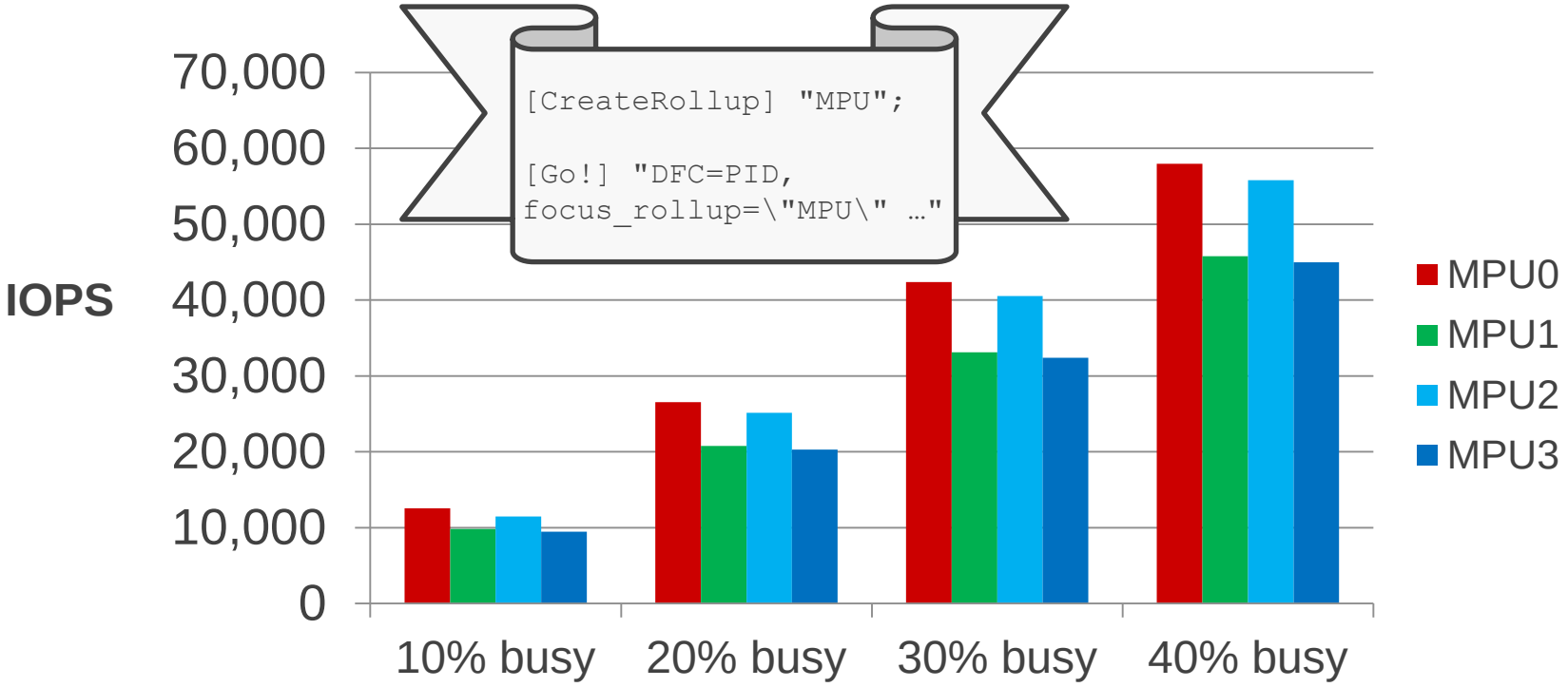
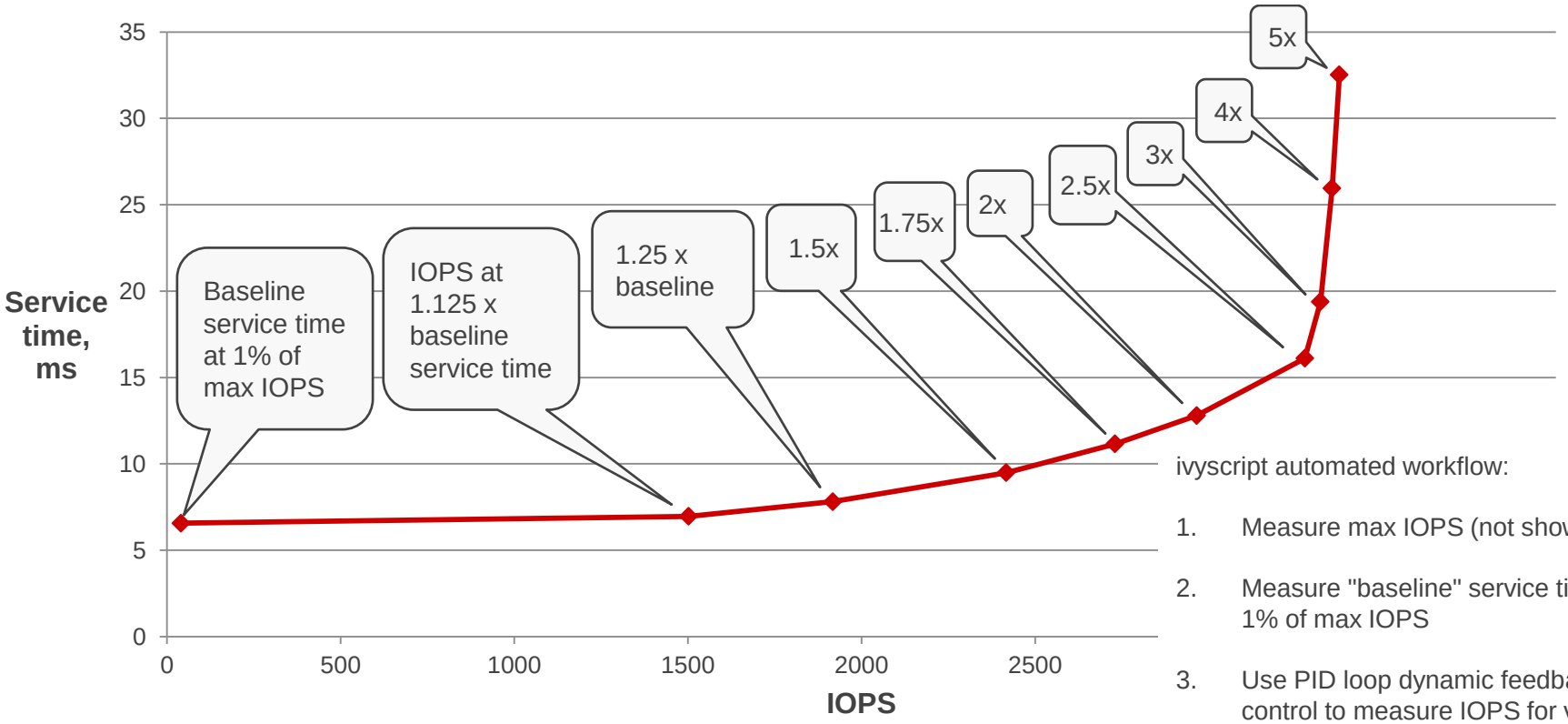


DFC on host workload data – non proprietary



ivyscript automated workflow:

1. Measure max IOPS (not shown)
2. Measure "baseline" service time at 1% of max IOPS
3. Use PID loop dynamic feedback control to measure IOPS for various multiples of baseline service time

Service time histograms

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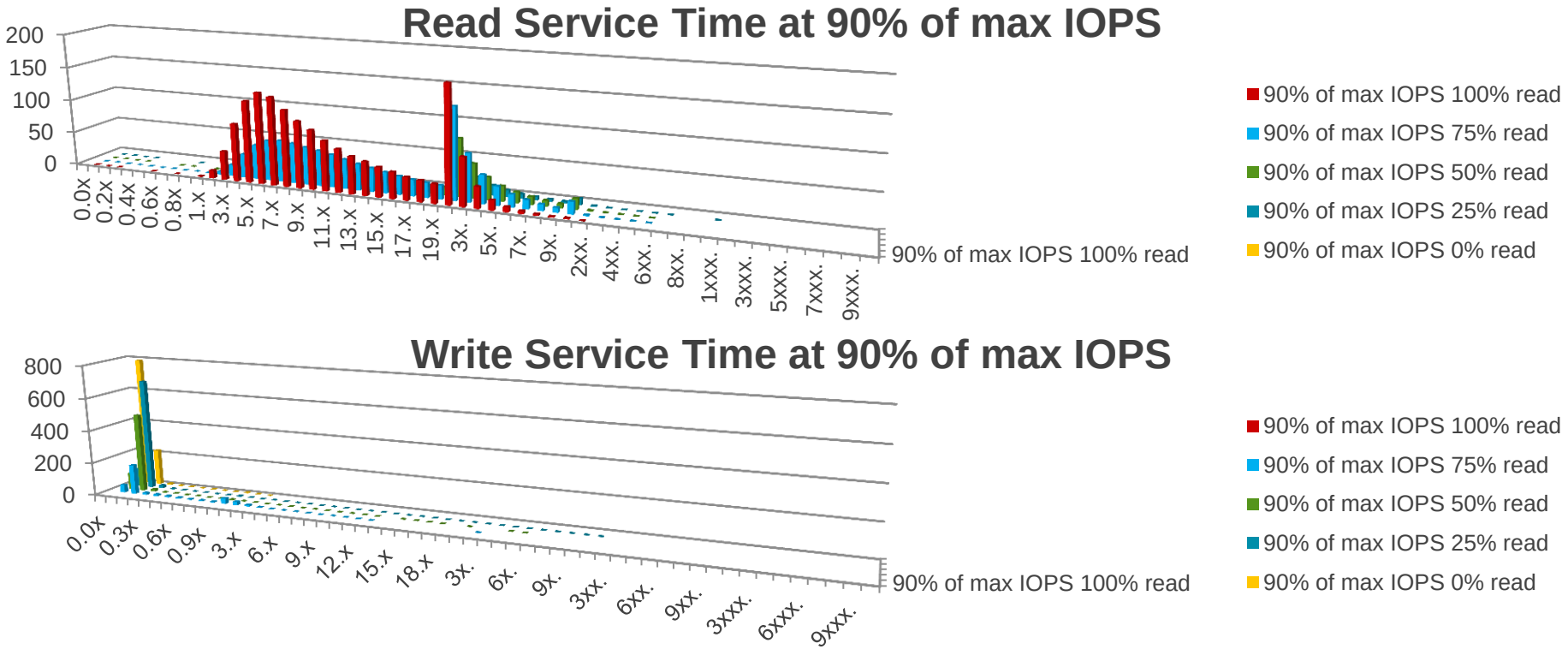

Workloads can be placed within the LUN

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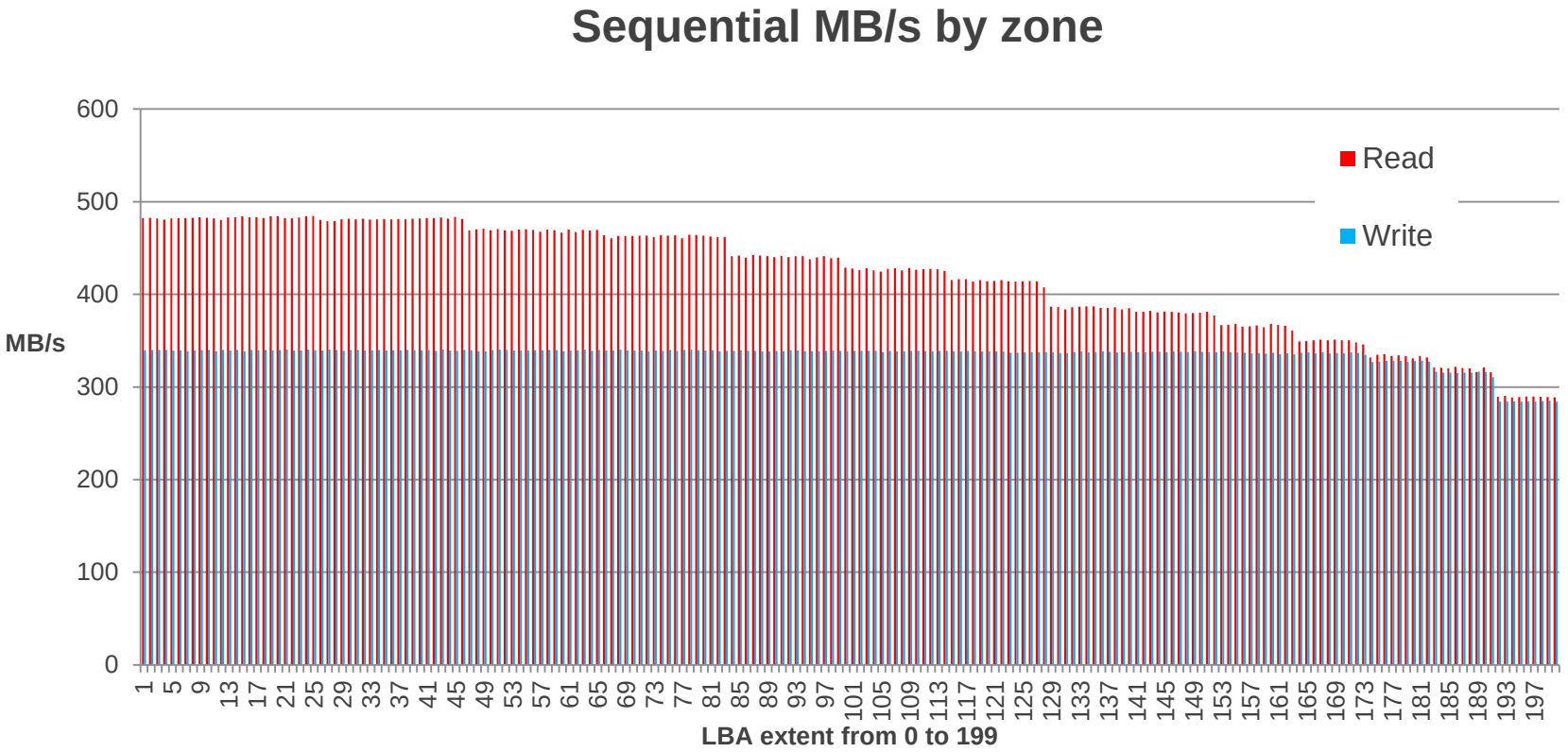

Ivy development status

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- May, 2016 initial version.
  - Ready for initial use by Hitachi internally
  - Approved for release as open source release. Now preparing HDS community site for opening for public access by end of May.
  - Demos available for all functionality.
  - No official QA performed (developer testing only), no end user experience yet.
  - Support for VSP Gx00, most, but not all command device data.
  - Support for HUS100 series.

Ivy futures

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- Need "shakedown" user experience before layering more development
- Dedupe / compression features – in development
- Some ideas for the future:
  - Repackage access to ivy engine via a RESTful API.
    - Build CLI on RESTful API to enable programming ivy in Python or any other language
    - Remove outer ivyscript programming layer wrapper, exposing ivy engine control statements as CLI commands.
  - Develop VSP G1000 support
  - Extend VSP Gx00 support
  - Develop "auto gain control" feature for PID loop
  - Transition to POSIX asynchronous I/O and port to other OS platforms.

Thank You

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