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PL/Container Introduction

Customize and Secure the Runtime and Dependencies of Procedural Languages

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Agenda

- The Problem
- What is PL/Container
- How to use PL/Container
- PL/Container Internals
- Future Work
- Q+A

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Greenplum Database

PL/Python

PL/R

PL/Container

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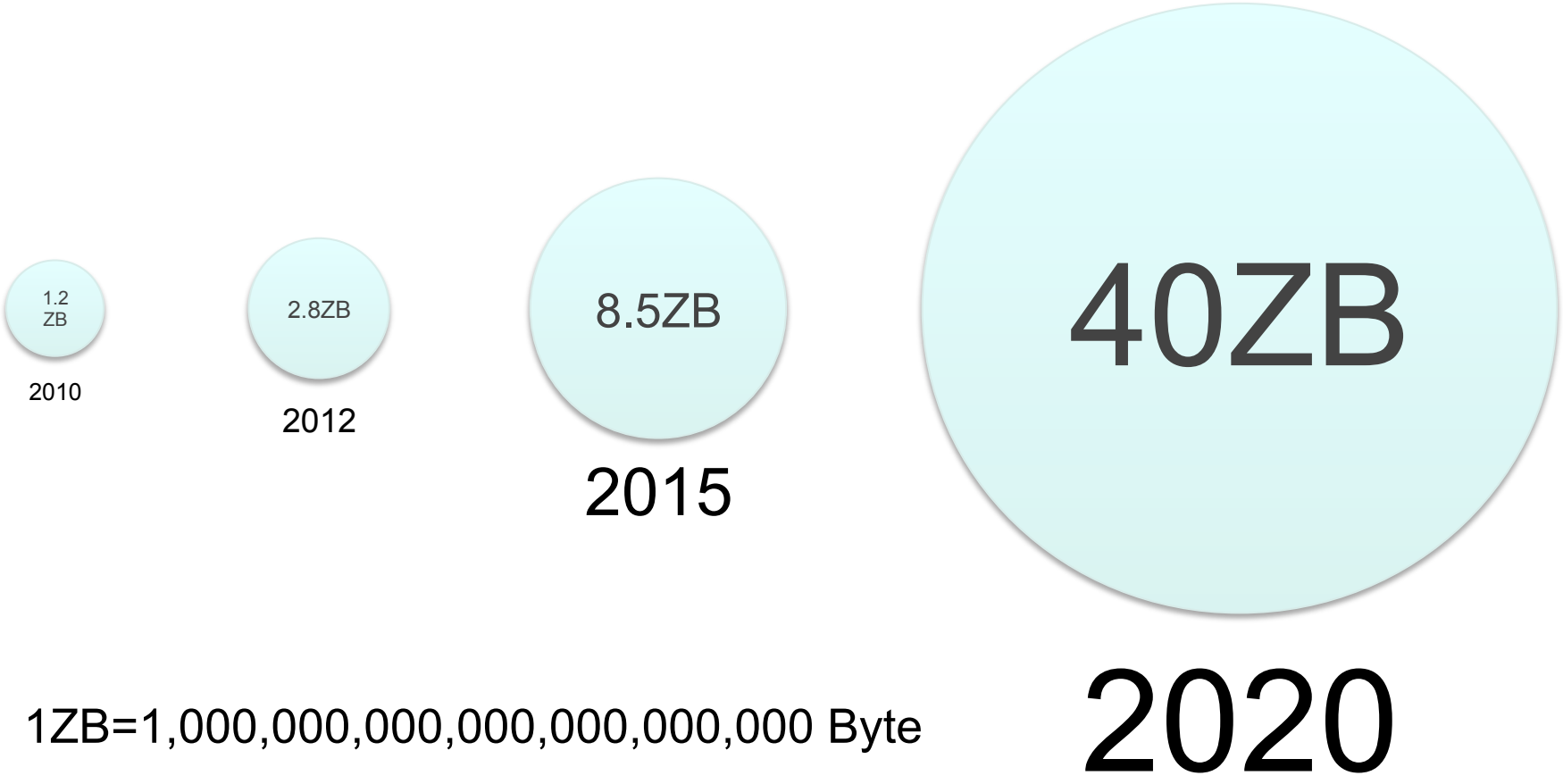
The Problem

We generate More and More Data

We generate More and More Data



1ZB=1,000,000,000,000,000,000,000 Byte

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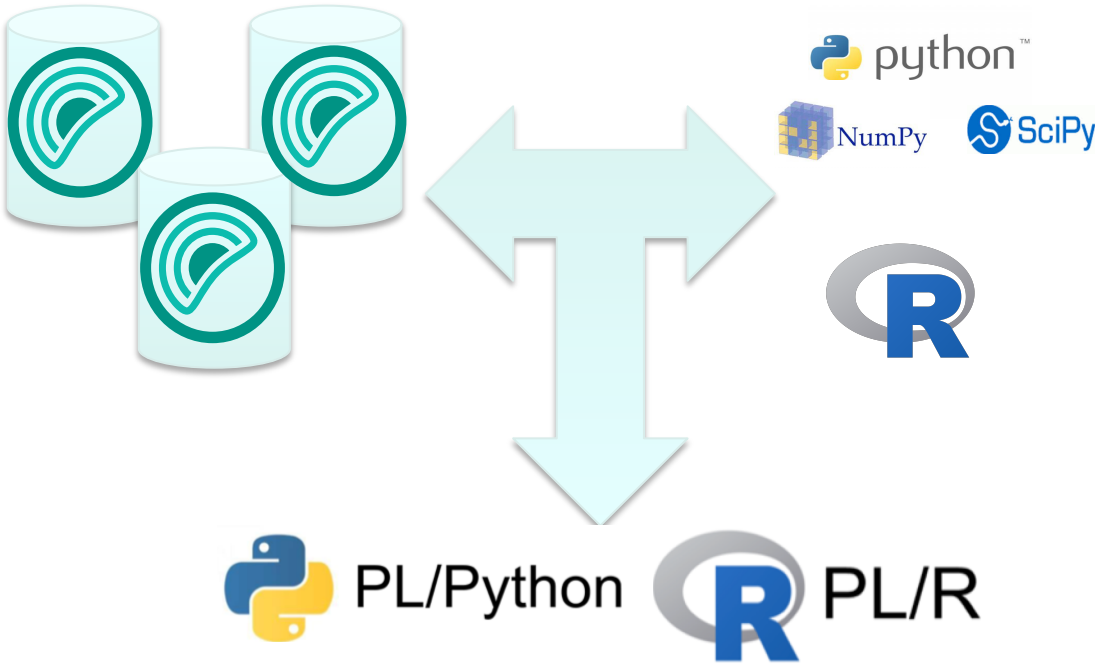
We want to analyze data for knowledge

We want to analyse data IN Database



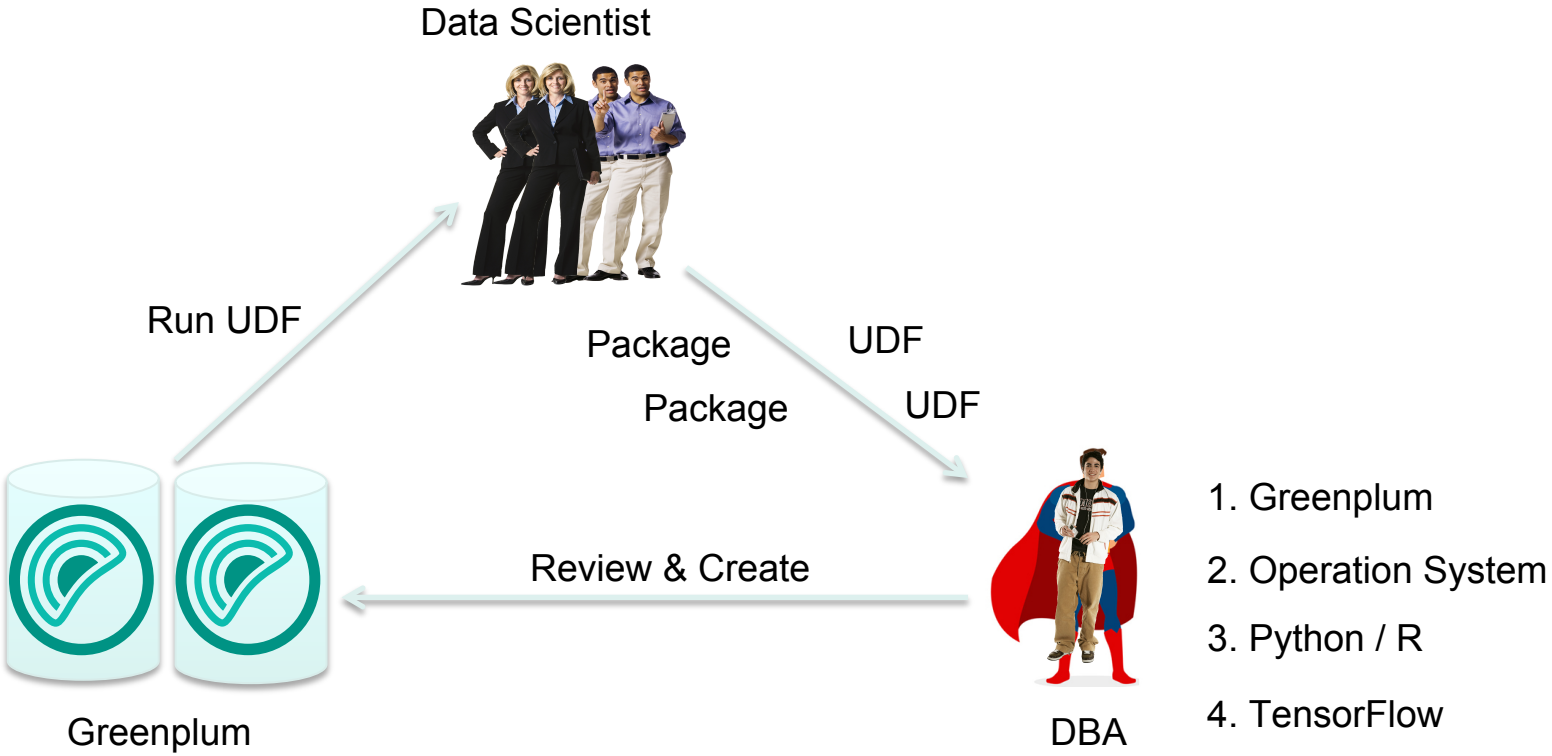
But…

PL/Python and PL/R are UNTRUSTED Languages

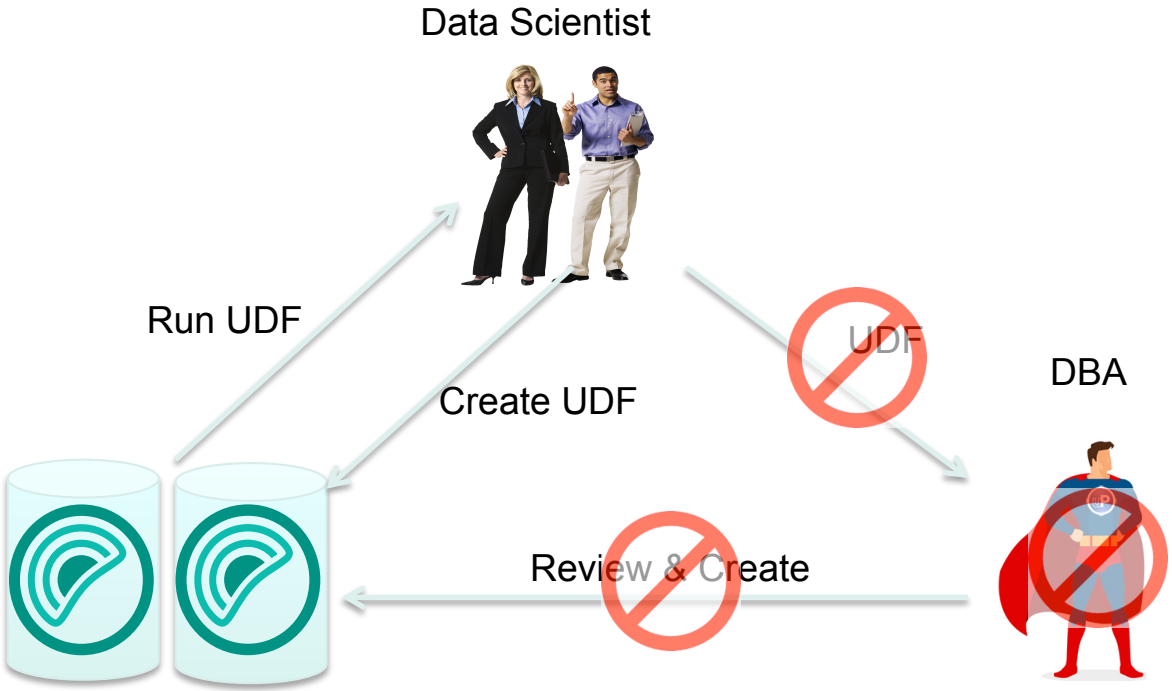
Only Superuser can Create UDF in Untrusted Languages

System(“rm -rf /data”)

The Problem: Triangle Dependency



Resolve The Problem: untrusted -> ~~un~~trusted



How to Make untrusted to ~~un~~trusted?

PL/Container

PL/Container

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What is PL/Container

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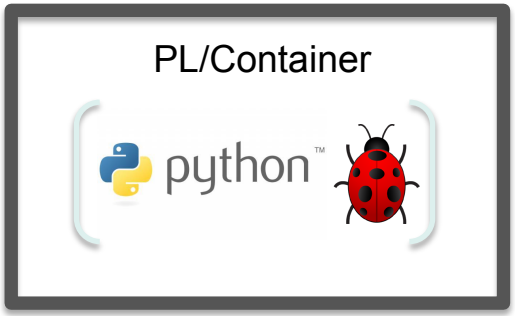
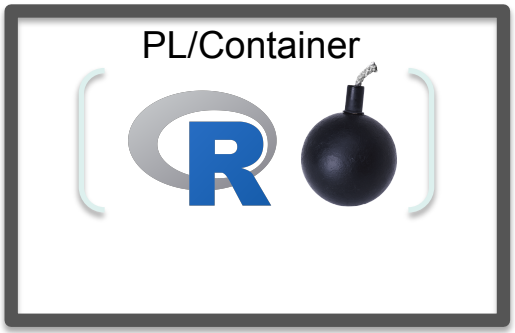
What is PL/Container?

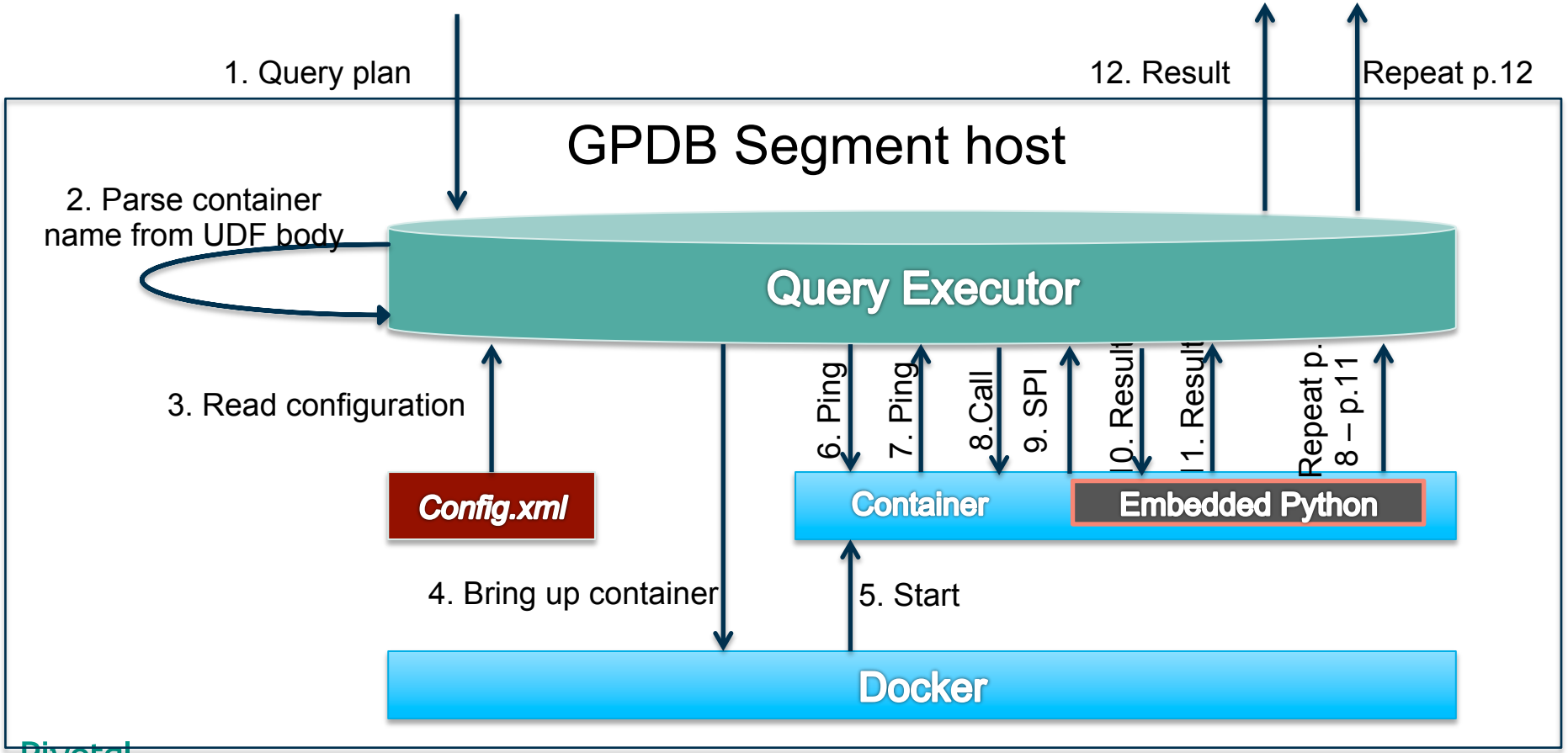
PL/Container is a customizable, secure runtime for Greenplum Database Procedural Languages.

- Greenplum Database Extension
- Stateless
- Based on Docker Container
- Customizable
- Secure
- Isolated





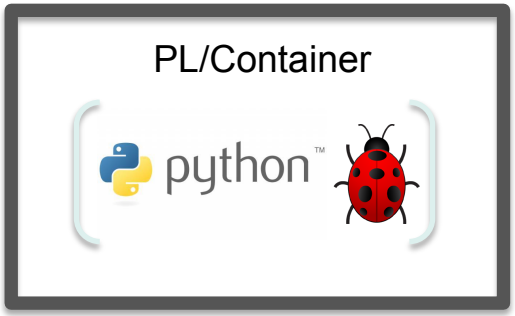
PL/Container Architecture

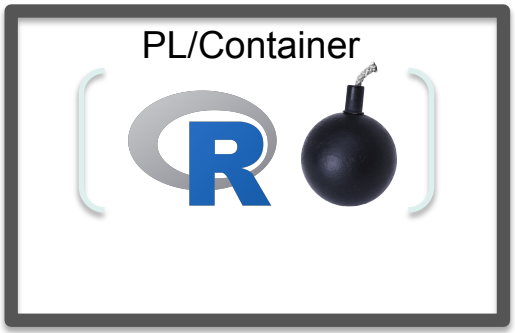


How UDF run in PL/Container?

PL/Container is a customizable, secure runtime for Greenplum Database Procedural Languages.

a. PL/Container Extension starts a docker container (only in 1st call)
b. Transfer UDF and data to docker container
c. Run the UDF in docker container
d. Contact the docker container to get the results





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How to use PL/Container

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Install PL/Container on Greenplum

Install from Source Code

- source $GPHOME/greenplum_path.sh
- make install

Install from GPPKG

- gppkg –i plcontianer-1.1.0-rhel7-x86_64.gppkg
- no additional dependencies

Prerequisites

Platform

Centos 6.6+ or 7.x

Database

Greenplum 5.2+

Docker

Docker 17.05+ on Centos7

Docker 1.7+ on Centos6

Build Custom Docker Image (optional)

Minimum Requirement:

- Python or R environment
- Add location of libpython.so and libR.so to LD_LIBRARY_PATH

```
FROM continuumio/anaconda

ENV LD_LIBRARY_PATH "/opt/conda/lib:$LD_LIBRARY_PATH”
```

Customize Your image:

- Install specific packages

```
FROM continuumio/anaconda3

RUN conda install -c conda-forge -y tensorflow
ENV LD_LIBRARY_PATH "/opt/conda/lib:/usr/local/lib:$LD_LIBRARY_PATH"
```

Configure PL/Container

XML

runtime

- **<id>**
- **<image>**
- **<command>**
- **<shared directory>**
- **<setting memory_mb>**
- **<setting cpu_share>**

container cgroup node
memory.memsw.limit_in_bytes
cpu.shares

Image

image add

image delete

image list

Runtime

runtime add
runtime delete

runtime backup
runtime restore

runtime edit
runtime show

Run PL/Container

Running a simple plpython UDF to calculate $\log_{10}$

```
postgres=# CREATE LANGUAGE plpythonu; plcontainer;

postgres=# CREATE OR REPLACE FUNCTION pylog10(input double precision) RETURNS double

precision AS $$

import math

return math.log10(input)

$$ LANGUAGE plpythonu;

postgres=# SELECT pylog10(100);
  pylog10
----------
         2
(1 row)
```

Run PL/Container

Running a simple PL/Container UDF to calculate $\log_{10}$

```
postgres=# CREATE EXTENSION plcontainer;

postgres=# CREATE OR REPLACE FUNCTION pylog10(Input double precision) RETURNS double
precision AS $$
# container: plc_python_shared
import math
return math.log10(input)
$$ LANGUAGE plcontainer;

postgres=# SELECT pylog10(100);
  pylog10
----------
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(1 row)
```

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How to use PLcontainer

Demos

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PL/Container Internal

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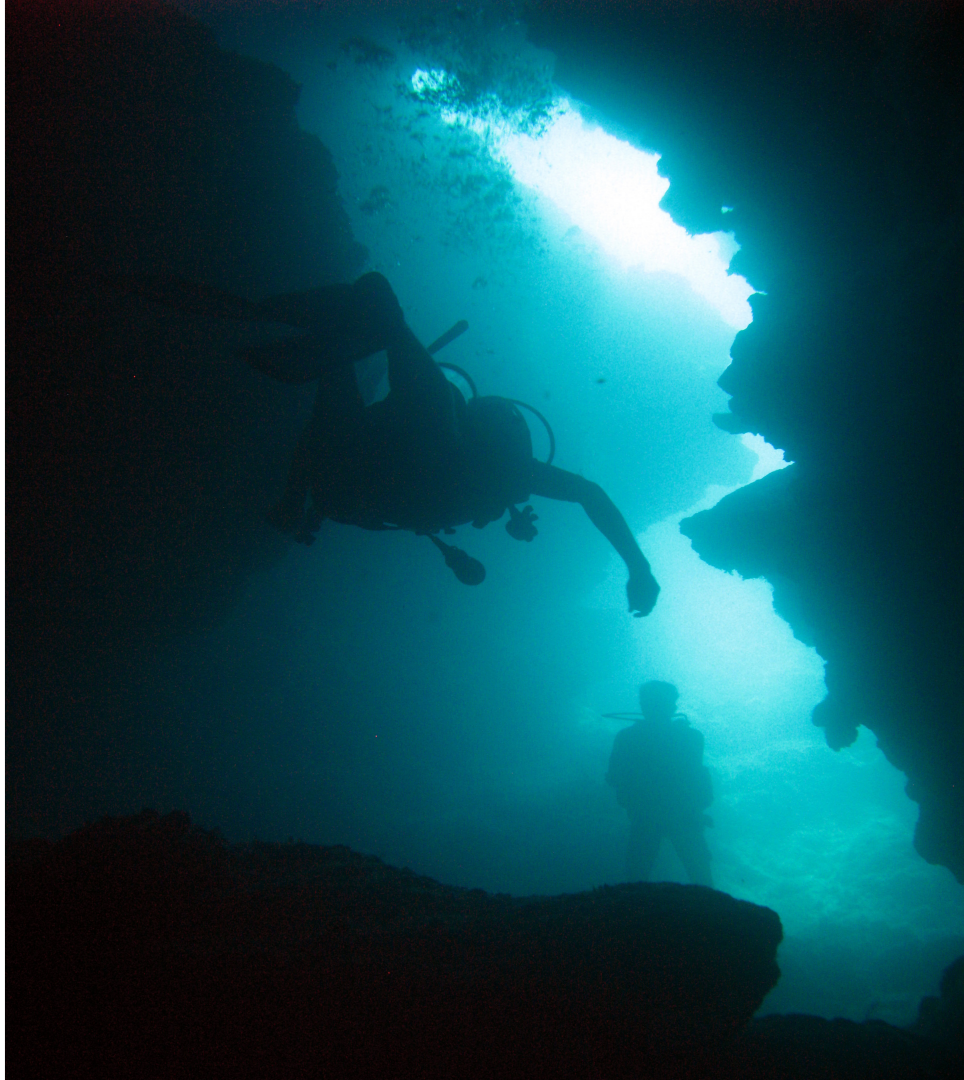
PL/Container Internals

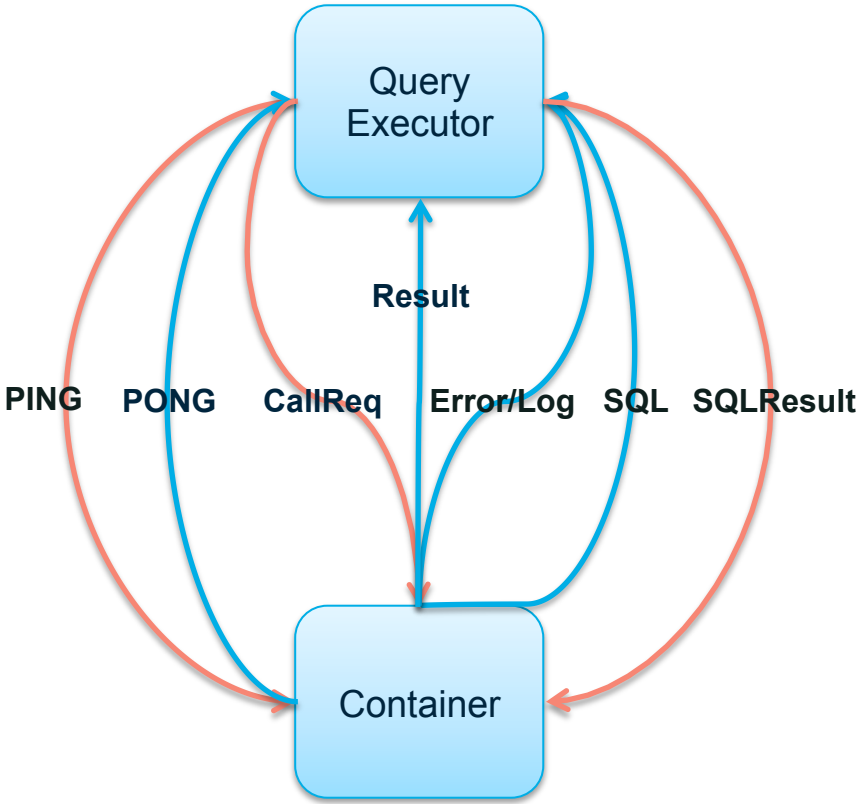
- Message Protocol
- SPI Support
- Pluggable Backend
- Resource Management
- Error Handling
- Performance



Message Protocol

PL/Container use messages to communicate between QEs and containers.

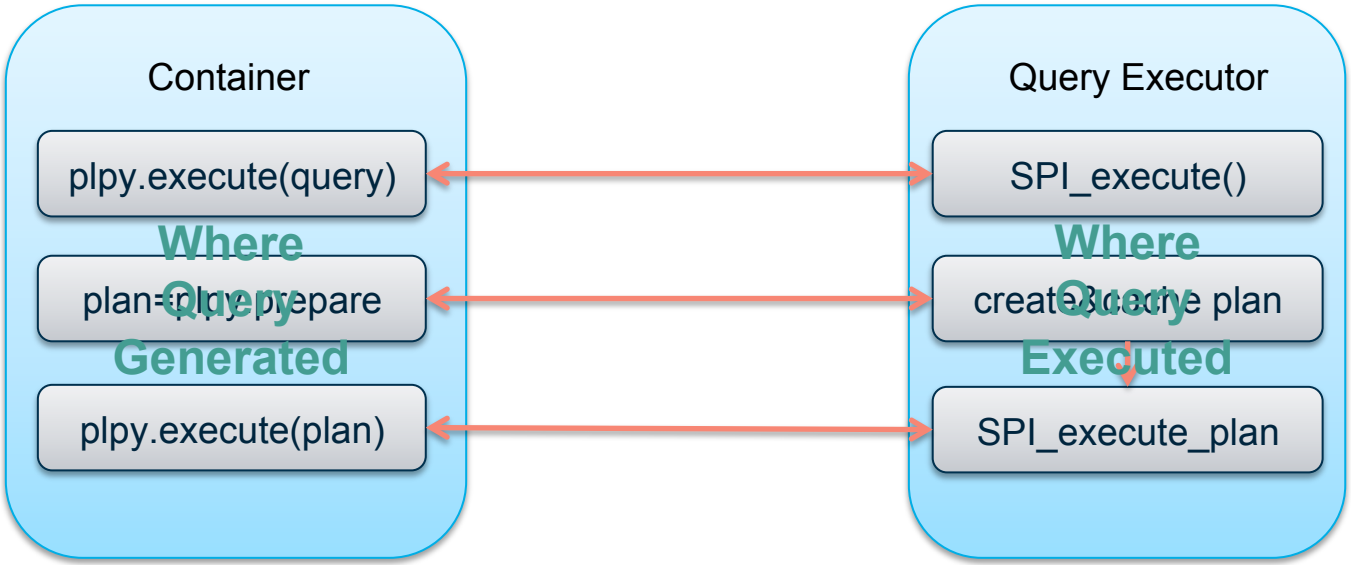
- plcMsgPing
- plcMsgCallreq
- plcMsgResult
- plcMsgError
- plcMsgLog
- plcMsgSQL
- plcMsgSubtransaction
- plcMsgRaw



SPI support

Server Programming Interface enable UDF to run SQL queries.

Problem: SPI is called inside container but executed at QE side.



Pluggable Backend

Separate Process

GPDB Query Executor

C CODE

Python Executor

Python C[illegible]e

Docker as a sandbox

docker

Container as a service

kubernetes

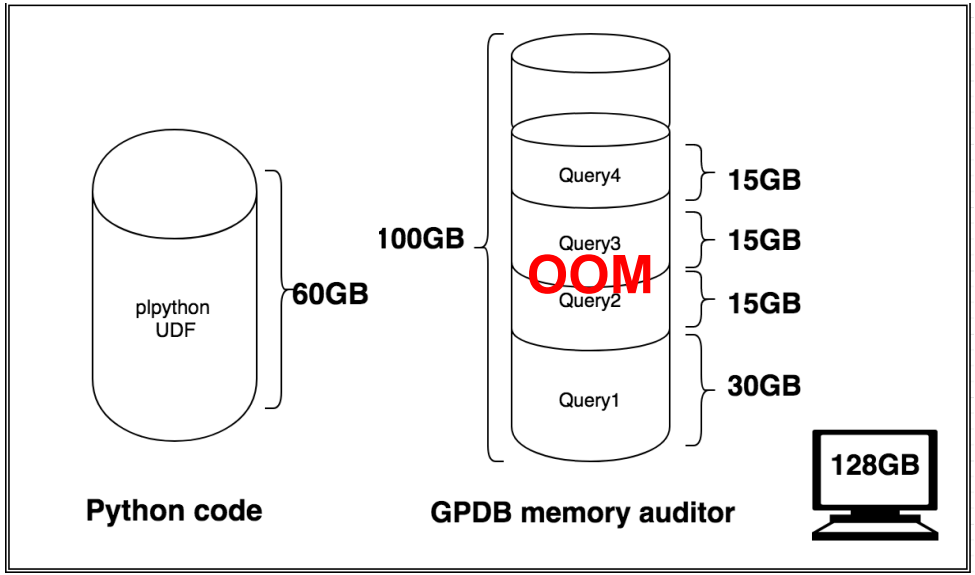
Resource Management

Container level

- Memory: memory limit, minimum is 4M
- CpuShares: relative weight of CPU

Extension level

- Integrated with GPDB resource group extension framework.



Resource Management

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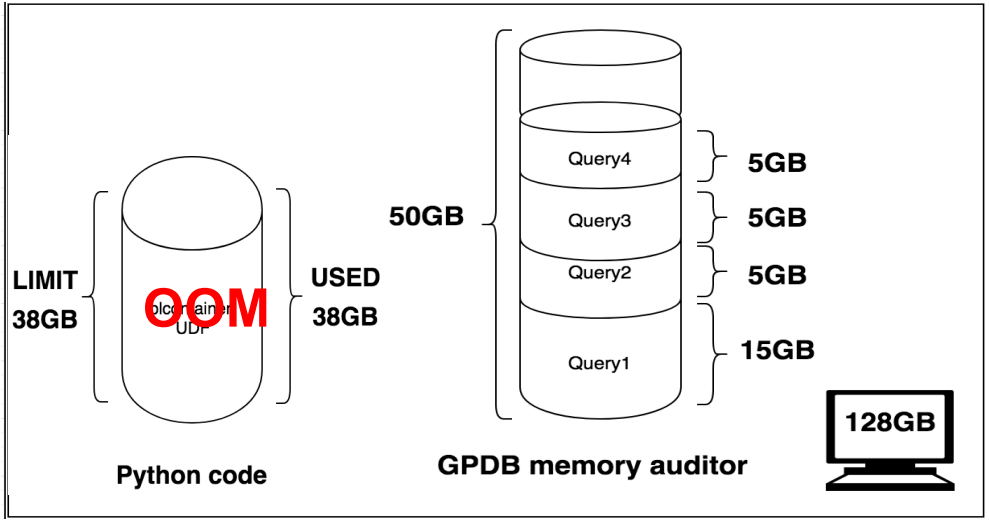
Extension level

- Integrated with GPDB resource group extension framework.

```
create resource group plgroup
(concurrency=0,
cpu_rate_limit=10,
memory_limit=30,
memory_auditor='cgroup')
```



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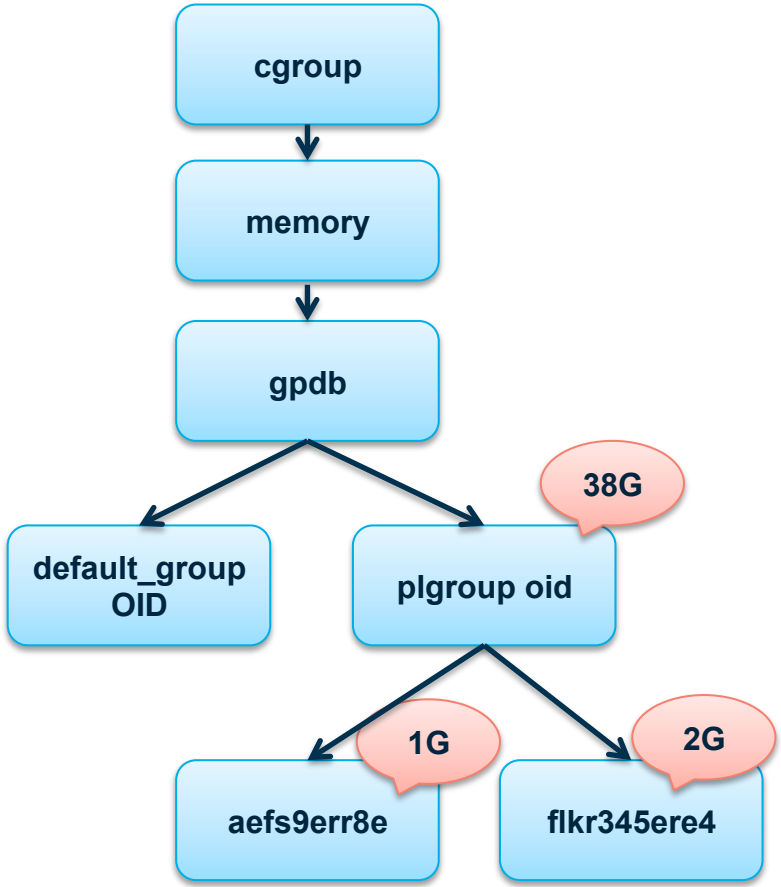


Error Handling

Container failure should not affect GPDB core

- Containers fail to create
- Containers fail to start
- Containers crash when running
- Cached containers crash

Container cleanup

- Query Cancel
- QE error
- Cached QE quit when idle for a long time (By Cleanup process)

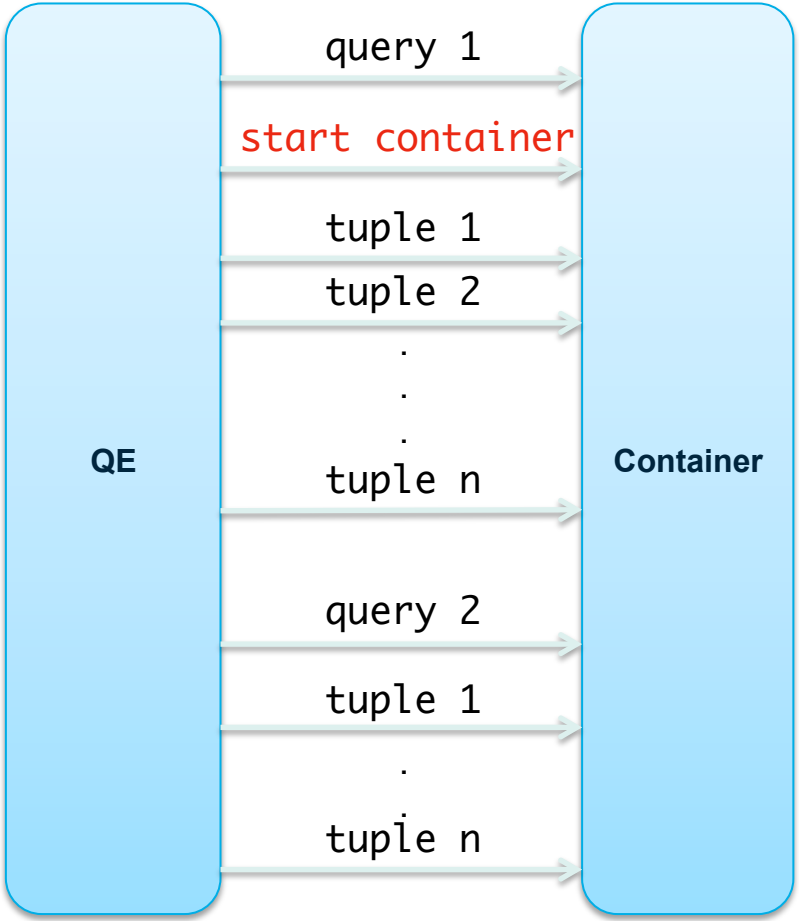
Performance

Optimization

- Cached container (lifecycle same as QE)
- Unix domain socket
- Type conversion
- Resource management (CPU share)

Best practices

- Array instead of multiple rows.
- Complex UDF instead of simple one



Performance

Test Environment

- Hardware: 6 virtual machines, each with 19G memory and 5 processors. (Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz)
- Software: Centos7, GPDB 5.2 with 30 segments.

Workloads

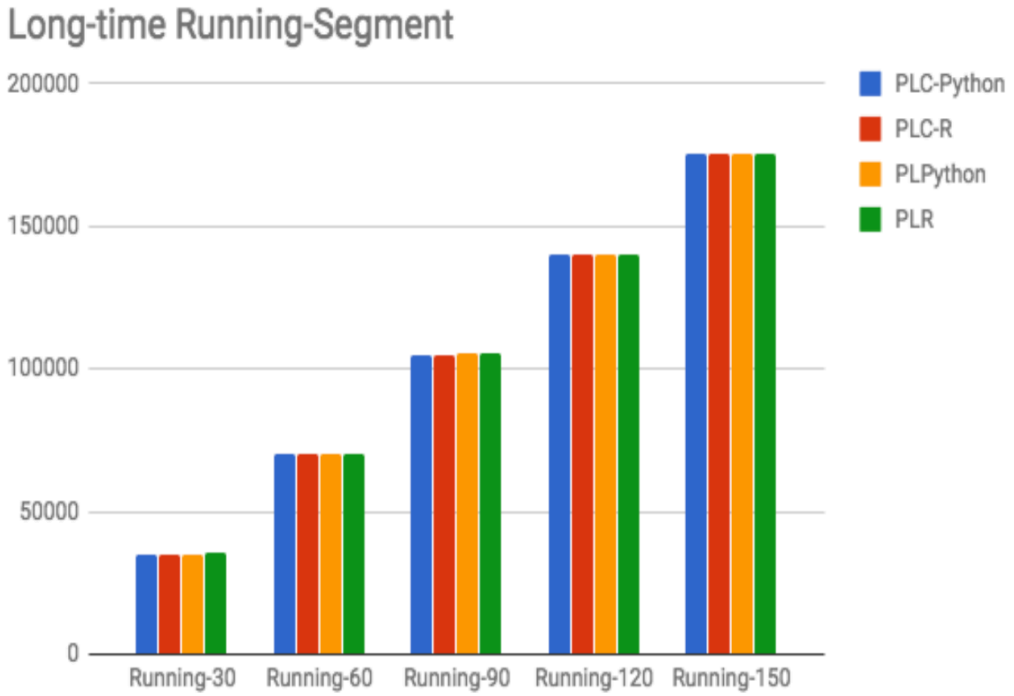
- Long-running function
- Large input array function
- Large output array function

Performance

Long-running function

```
CREATE OR REPLACE FUNCTION pysleep(i
int) RETURNS void AS $$
# contaziner: plc_python_shared
import time
time.sleep(i)
$$ LANGUAGE plcontainer;

SELECT count(pysleep(1)) FROM tbl;
```



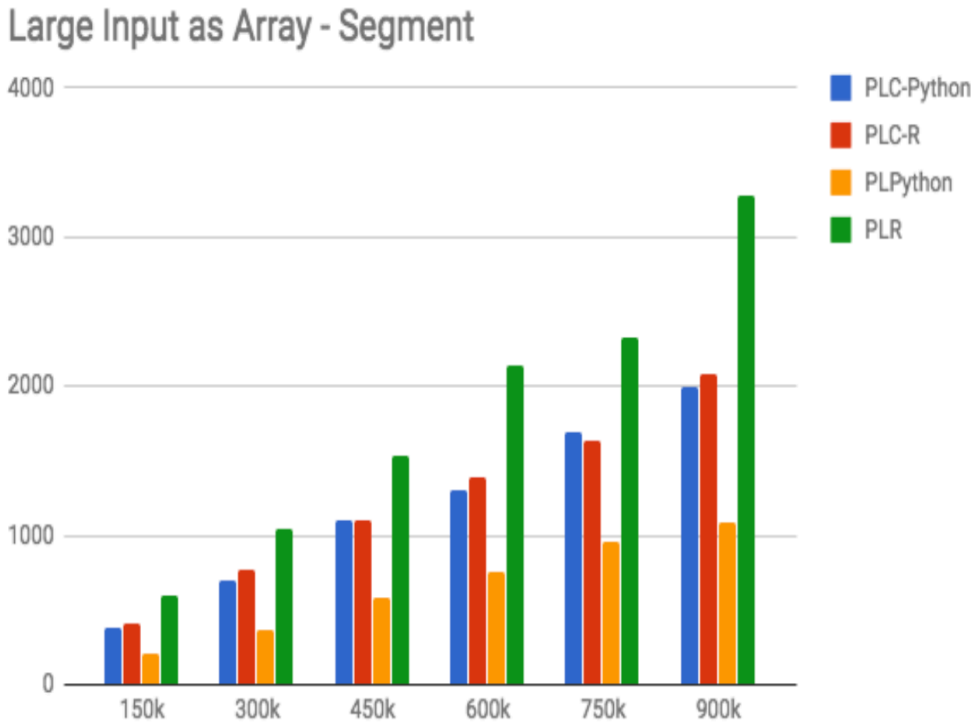
no performance downgrade

Performance

Large input array function

```
CREATE OR REPLACE FUNCTION
pylargeint8in(a int8[]) RETURNS float8
AS $$
#container : plc_python_shared
return sum(a)/float(len(a))
$$ LANGUAGE plcontainer;

SELECT count(pylargeint8in(ARRAY(SELECT
column1 FROM tbl1))) FROM tbl2;
```



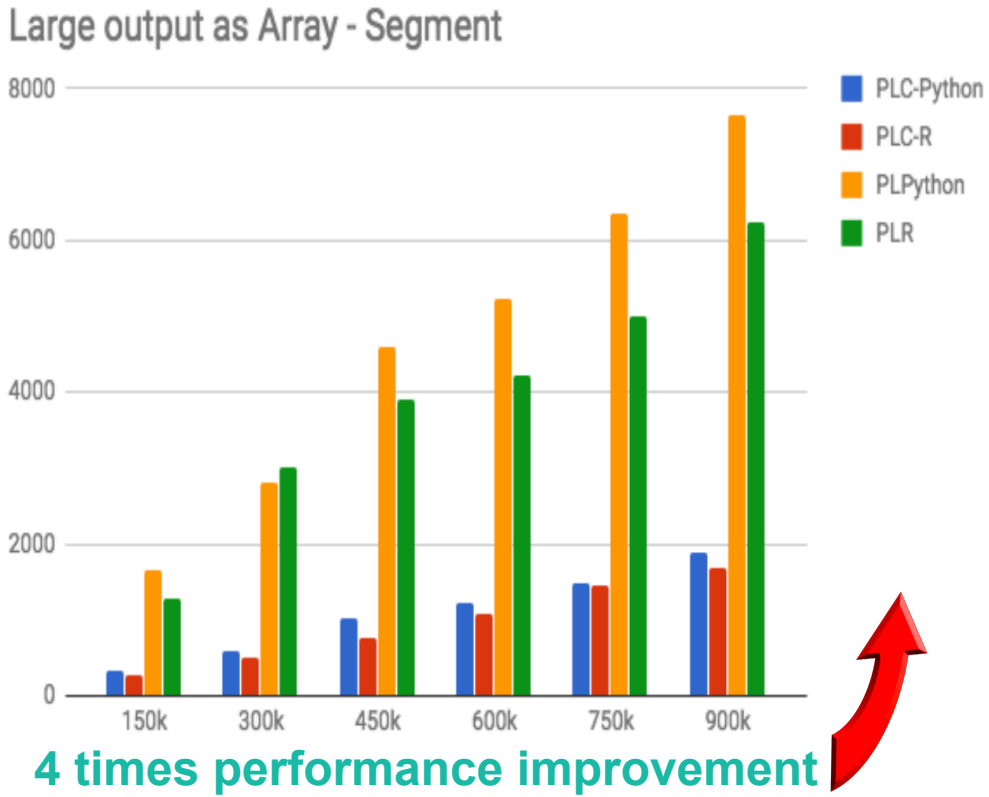
2 times performance downgrade for Python
30% performance improvement for R

Performance

Large output array function

```
CREATE OR REPLACE FUNCTION
pylargeoutfloat8(num int) RETURNS
float8[] AS $$
# container: plc_python_shared
return [x/3.0 for x in range(num)]
$$ LANGUAGE plcontainer;

SELECT count(pylargeoutfloat8(n)) FROM
tbl;
```



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Future Work

PL/Container Future Work (subject to change)

Container Orchestrater / Cloud

kubernetes

Pivotal Container Service™

Support More Languages

Programming

ANACONDA®

Support More Technology

TensorFlow

Keras

https://github.com/greenplum-db/plcontainer

https://gpdb.docs.pivotal.io/570/ref_guide/extensions/pl_container.html

Transforming How The World Builds Software