Experiments with Docker and Spark

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VizieR & Docker Apache Spark (& Docker)

Use case & data

Test beds, experiments and what we learned Perspectives



VizieR & Docker

- VizieR is deployed on several mirrors
- Hosts with different Linux distributions, kernels, etc.
- Docker as a solution to deploy "quick and easy" ?



Tools related to VizieR

VizieR mirror update process

- Typical installation of VizieR
 - Dependencies and CGI scripts transfer through Rsync and scp
 - Dependencies installation with the package manager
 - Compilation of the dependencies only available as sources (developed at CDS)
 - CGI files copy and Apache configuration
 - Apache start

To a VizieR Docker image...

- Prototyping following the previous process
 - Resolution of missing packages (like gcc, make, rsync, .., not present in the Apache image)
- To an optimized version
 - Sources directly from CVS
 - CGI scripts and static files in a Docker volume (between the host and the container), these files will be updated through scripts (executed at each container start and via a cronjob service (on the host)
 - Path corrections
 - Also use of Portainer (Simple management UI)

VizieR & Docker at the End



And now

- Will be used in a first step inside CDS
 - To test Docker use on a mid-term basis
 - To install local "VizieR" to test it before update
- Needs discussion and agreement with at least one host (in a first step) to start to use it "in production" all over the world !



Apache Spark

• "Apache Spark is a cluster computing platform designed to be fast and general purpose."

 It extends the MapReduce model to support more types of computations (interactive queries, stream processing, etc.) and it offers APIs for Scala, Java, Python, R,...

MapReduce



Credit: G. Fedak, INRIA

Apache Spark, so quick ?

- Computations in memory (as much as possible, otherwise pilling to the disks)
- Introduction of data models
 - RDD (Resilient Distributed Datasets)
 - Immutable distributed collection of elements
 - Operations: Transformations (map, filter, etc.), Actions (reduce, count, etc.)
 - Datasets to represent tabular data, queryiable via SQL
- It uses mainly Hadoop Distributed File System (HDFS).

Other technical aspects

- Introduction of Docker (components) and Drone (continuous integration) to "automate" the deployment process and to focus mainly on the development side. It is becoming easy to migrate to external resources when needed.
- Use of Scala which is native in Spark (a part of the Java API is "experimental").





Use case & data

- The "cross-match" of (large) source catalogues.
- Examples:
 - 2MASS¹, 470,992,970
 - SDSS² DR9, 469,053,874



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Credits: http://healpix.jpl.nasa.gov/

Fuzzy join between 2 tables (A and B) of several hundred millions of data

22/03/2017

ASTERICS TechForum, 22-23/03/2017, Strasbourg

Not distributed but...

• organised and stored on one server (2x10 cores, 64GB, 12TB (15k tours))



The sky is cut into diamonds of the same size, pixels, each source or sky object is a numbered pixel.

Illustration: X-Match frontend

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Illustration

 A X-Match implementation in MapReduce, couples (Key = pixel number, Value)

- Side effects
 - Fuzzy join
 - Source duplication in the neighbour cells if needed





Credits: HEALPix – arXiv:astro-ph/0409513

Test beds: hardware & software

- Internal resources to learn / prototype
 - 6 nodes (4 cores, 16GB, 1 TB), Ubuntu
- External resources renting (Experiment 1)
 - 12 nodes, 4 cores, 32GB, Raid 2*2TB, Ubuntu (8000€ / year)
 - Configuration was defined "ad hoc" and low cost
- Collaboration with IN2P3 (Experiment 2)
 - 9 nodes (only one VM per physical server, CentOS), 24 threads (-> 216 threads), 64GB (-> 576 GB) -> possible X-Match of billion sources

Test beds: hardware & software

- Software side:
 - Apache distributions of Spark (1.5.0 to 2.0.2) and Hadoop (2.6 to 2.7.3)
 - Java, Scala
 - Docker, Drone, ...

Experiment 1 (12 nodes)

- Input data (SDSS DR7 (primary sources) and 2MASS): 54GB and 58GB file size; 357 175 411 and 470 992 970 elements
- Output data: 49 208 820 elements

X-Match service reference time was: 10 minutes

Cross-Match (source duplication done	in phase 2 wi	th all the d	ata as outp	ut)				
HDFS block size= 128MB for the input	files ; sdss7.c	sv and t 2n	nass.csv re	plicated 2	times			
HashPartitioner	60 partitions							
HDFS output files size	32MB							
Number of nodes Spark/HDFS	5	7	9	10	11			
Phase 1: prepare	23,0	16,0	14,0	14,0	13,0			
mapToPair (sdss7.csv)	5,1	4,9	4,9	4,8	4,7			
saveAsHadoopFile (sdss7.bin)	5,7	2,7	2,0	2,3	1,5			
mapToPair (2mass.csv)	5,7	5,2	5,2	5,1	5,0			
saveAsHadoopFile (2mass.bin)	6,5	3,6	1,9	1,6	-			
Phase 2: join	31,0	21,0	13,0	11,0	9,9			
mapToPair (sdss7.bin)	7,2	4,7	3,5	3,0	2.0			
flatMapToPair (2mass.bin)	11,8	8,3	5,5	4,9	4,3			
saveAsTextFile (crossMatch_D.txt)	12,0	7,6	3,4	2,4	2,3			
TOTAL	54,0	37,0	27,0	25,0	22,9			
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What we have learned

- Time was similar to the X-Match service from 11 nodes
- Keys common to 2 RDDs are not necessarily on the same node
 - It implies a transfer overhead between the nodes during the join => impact on the performances
 - We had clearly a bottleneck in the join phase ("shuffle")
 - "block affinity groups" is an on-going work at Apache.
- We spent time on the "data co-location"
- We found a solution to do it "manually" via Python scripts.

Experiment 2: IN2P3 cluster

- Gaia X IGSL3 (> 1 billion sources each)
- Time divided by 2 compared to the production X-Match Server





Perspective and conclusion

- Apache Spark quick to install, easy to use for common tasks
- But not easy to understand what happens, how it works when you have particular use cases
- Real interest in several communities
- Docker use will continue with an application to the X-Match service

Links

- Apache Spark, <u>http://spark.apache.org/</u>
- Apache Hadoop, <u>http://hadoop.apache.org/</u>
- <u>Spark : Cluster Computing with Working Sets</u>, Matei Zaharia, Mosharaf Chowdhury, Michael J. Franklin, Scott Shenker, Ion Stoica, University of California, Berkeley, <u>http://static.usenix.org/legacy/events/hotcloud10/tech/full_papers/Zaharia.pdf</u>
- <u>Optimizing Shuffle Performance in Spark</u>, Aaron Davidson, Andrew Or, UC Berkeley, <u>http://www.cs.berkeley.edu/~kubitron/courses/cs262a-</u> <u>F13/projects/reports/project16_report.pdf</u>
- <u>Resilient Distributed Datasets : A Fault-Tolerant Abstraction for In-Memory Cluster</u> <u>Computing</u>, Matei Zaharia, Mosharaf Chowdhury, Tathagata Das, Ankur Dave, Justin Ma, Murphy McCauley, Michael J. Franklin, Scott Shenker, Ion Stoica, University of California, Berkeley, <u>https://www.cs.berkeley.edu/~matei/papers/2012/nsdi_spark.pdf</u>
- JavaSpark Api, <u>http://spark.apache.org/docs/latest/api/java/</u>
- HEALPix, <u>http://healpix.jpl.nasa.gov/</u>

Additional slides

- Data preparation and Join
 - The process
 - Its translation in Java

First experiment (SDSS DR7 X 2MASS)

Data preparation phase



Example, Java API

Data preparation phase of our use case



First experiment (2)

Join phase



Example, Java API (2)

Join phase of our use case





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