ATLAS Data Flows & Rucio

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A candidate event display for the production of a Higgs boson decaying to two b-quarks (blue cones), in association with a W boson decaying to a muon (red) and a neutrino. The neutrino leaves the detector unseen, and is reconstructed through the missing transverse energy (dashed line). (Image: ATLAS Collaboration/CERN)

m_{bb} [GeV]

ATLAS computing usage





ATLAS computing usage





Basic experiment data flows 1/2



Original ATLAS computing model designed as static **clouds**

ATLAS Clouds ≠ "Cloud computing"
Mostly national or geographical groupings of sites
Common funding agencies
Support often using the same language

Model had a series of shortcomings

Individual tasks **inflexibly executed** within a static cloud All tasks **output aggregated** at the 10 Tier-1s The **Tier-2 storage** was not optimally exploited **High priority tasks** were **occasionally stuck** at small clouds



Basic experiment data flows 2/2



WLCG networks have evolved significantly in the last decades

Limiting transfers within a single cloud no longer necessary Now single WORLD cloud site concept

Nucleus

Any stable site can aggregate the output of a task Site can be manually assigned as a nucleus

Satellites

Process the jobs and send the output to the nucleus Defined dynamically for each task No longer confined inside the original cloud

Currently around **130 active sites** used by ATLAS





Experiment job types

Global shares are employed to allocate the available resources among the activities

Done on **agreement** between the various production and physics groups **Hierarchical** implementation

Related activities have the opportunity to inherit unused resources

Essentially two categories of jobs

ProductionData reprocessingEvent generation / Simulation / ReconstructionGroup production

Analysis User analysis Group analysis

The main activity at a given time can depend on many things

Data **reprocessing** or Monte Carlo **production** campaigns **Conference** deadlines, need for an increase for user analysis Global **pandemics**





Data transfer rates

A few numbers showing the ATLAS scale

1B+ files, 800+ PB of data, 400+ Hz interaction 120 data centres, 5 HPCs, 3 clouds, 1000+ users 1.5+ Exabytes/year transferred

3+ Exabytes/year uploaded & downloaded

Increase 1+ order of magnitude for HL-LHC



750P

500P

250P



Thursday, 12 Oct 2023

• Bytes: 821 766 309 649 510 300

10/01

Data management

Rucio handles all data management for ATLAS

Creation, location, transfer, deletion, annotation, and access Orchestration of dataflows with both low-level and high-level policies Coherent interface required to allow smooth data handling for production and users We also have data management internal flows (recovery, rebalancing, ...)

ATLAS sites are not homogeneous

Different storage, different protocols Abstracted by FTS, GFAL and Davix

ATLAS deployment

Two FTS servers in production Plus regularly the pilot & test services

Average file flow rate

1+ million successful transfers per day
 200k failed transfers per day
 Constant background failures
 Biased because of quick retries
 Peaks mostly site configuration problems









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Data policies

Vast majority via subscriptions

RAW Export DAODs to T2 disks T0 spillover

• • •

Special use cases

Replication **P**olicy on the **G**rid e.g. migrate small files to T2

RPG functionality

Being merged into subscriptions Going away hopefully soon

| Subscriptions | | | | |
|--|---------------|--|----------------------|-------------------------------------|
| Show 100 - entries | | { | | MigrateArchiveData.conf |
| Name | 1 01 | "scope": ["mc.* .*TeV" | 1. Ohuda | MigrateArchiveMC.conf |
| Name | - OK | 1 | ÷ Stuck | |
| Tunctional Test | 1109792 | "datatype": [| 2/22 | MigrateDataDAOD.conf |
| Backup from INEN-T1 | 2609 | "DAOD .*" | 0 | |
| data DAOD to pon-nucleus disk | 133278 | 1. | 26 | MigrateMCDAOD.conf |
| DATA TAGS to CEBN DATADISK | 265 | "transient": [| 0 | |
| data15_13TeV TAGS p2685 to CEBN DATADISK | 92 | "None". | 0 | MigrateSmallFilesToT2.conf |
| Enhanced bias for HI T | 110 | "0" | 0 | • • |
| EVNT to 2 T1s | 31629 | 1. | 0 | MigrateToContainerMC conf |
| EVNT to 2 T1s 1 year | 24529 | "prod_step": [| 0 | - migraterocontainermeteon |
| EVNT to T0 with 1 year lifetime | 12848 | "merge" | 0 | AligratoToContainorMC15Evet conf |
| group.phys-gener to CERN-PROD PHYS-GENER | 5344 | "deriv" | 0 | Migrate rocontainer wich sevint.com |
| MC TAGS to CERN DATADISK | 714 | 1 | 0 | |
| MC15 DAOD to T2 disk | 30434 | "did type": [| 4 | Migrate to TapeData.com |
| mc15_13TeV TAGS p2671 to CERN DATADISK | 6 | "DATASET" | 0 | |
| mc15_13TeV TAGS to CERN DATADISK | 101 | I | 0 | State to tapeDataAOD.conf |
| mc15_13TeV TAGs to CERN DATADISK | 1 | "split rule", true | 0 | telles a real cases of |
| MC16 NTUP_PILEUP datasets to CERN DATADISK | 179090 | i spere_rute : true | 0 | MigrateToTapeMC.conf |
| non-T0 HIST to CERN disk | 761 | J | 0 | |
| PHYS-GENER_inputs | 65968 | 0 | 0 | MigrateToTapeMCReconAOD.conf |
| sit*PAC archival to TAPE | 1 | 0 | 0 | |
| T0 AOD to non-nucleur | 400 | ^ | 0 | 🌣 MigrateToTapeMCT01.conf |
| T0 AOD to non-nucleu | | | | |
| TO AOD to nucleus "lifetime": 25 | 92000 | | | MigrateToTapeMCT2.conf |
| TO AOD to nucleus (D "copies": 1. | 52000, | | | |
| To AOD to nucleus (To "rse expressio | n": "(tier<3& | type=DATADISK&datapolicyanalysis=true&data | policynucleus=false) | MigrateToTapeValid.conf |
| TO DAOD to T1 disk "activity": "D | ata Consolida | ition", | | |
| TO DESD to T1 tape "weight": "fre | espace" | | | M README.md |
| T0 DRAW to T1 disk | | | | |
| T0 DRAW to T1 tape | | | | P RPG.conf.template |
| T0 HIST to CERN disk | 16544 | 1 | 0 | U |
| T0 RAW to T1 tape | 73835 | 2 | 1 | RPG crontab |
| T0 spillover to CERN-PROD_DERIVED | 25 | 0 | 0 | |
| Validation HITS and NTUP | 6717 | 0 | 0 | PRG pv |
| Validation RDO, ESD, AOD and HIST | 2199 | 0 | 0 | re krupy |



Central data management operations



Following up transfer issues Rucio deployment operations User/client support

Getting disk space under control

Obsoletion campaigns

Lifetime models (and exceptions)



Ops dashboard 1/2



397 7.01 K













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Ops dashboard 2/2





Deployment / usage





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14

HL-HLC Data Roadmap



Next data challenge jumps from 10% (960 Gbps) to 25% (2400 Gbps) of HL-LHC needs

Large single step increase of volume in the decade-long plan - had to reduce from 30% Need to reconsider due to new HL-LHC schedule and hardware purchasing

With communities beyond WLCG, such as DUNE, SKA, Belle II, JUNO, ... and the NRENs

We spend a considerable effort to share our data management stack Allows us to **work together** on these shared challenges

One interesting point: For the middleware stack, the volume is rather irrelevant

Number of files total, and number of files processed is the key metrics ATLAS stance on **big files vs. lots of files** not yet decided

Transfer throughput per destination Tier





Year



2023-10-16



Death by spreadsheet



DC24 is coming in February

Lots of lessons learnt from previous Data Challenge

Rucio did very well (and so did FTS!) However, injection had a distinct sawtooth-pattern Multi-hour cycle now revised to 15 minutes

Updated rates and new methodology

Original distinction in minimal and flexible model Adapted to reality

> Tier-0 export flows match LHC machine rates Tier-1 and Tier-2 flows match processing

Ramp up challenges with new Rucio injection tools

Expect first plots at Data Challenge workshops

| | 100.0 | 1 5 3 | 1.10 | 125 0 | Defaul. | - <u>n</u> | + B | 1 0 | 4 9 | ⊞ 8 | · E · · | 4 • M • | A . 6 | | 7.8- | 2 . | * | | | | | | | | | | |
|----------------------------------|--------------|-----------|-------------|---------------------|-------------|---------------|---------------------|-------------|---------------|--------------|--------------|-------------|-------------|-----------|--------------|--------------|--------------|---------------|--------------|---------|--------|------------|--------|--------|-----------|------------------------|---------------|
| · fc. meanth-series, | 2 - Section) | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A | đ., | | Ð | e | | 6 | 8 | | | - K | | w | N | | 9 | 0 | | . 6 | | | | | × | | | AA. | Að |
| lodei (1 = minimal, 2 = flexible | 0 2 | Al normal | transfers y | early avg | . 1 | Scale TO e | FALSE | AI T2 ste | FALSE | T2 uplink (C | 1 | 2 cont fact | 3.65 | T2 capped | 500% | Fliesize (M | 3072 | Del. int. (h) | 24 | | | | | | | | |
| | - | Match TO- | export with | T1 ogress | (really - 2 | 022 data taki | ng T1 ogre | ics was 3.2 | 2x T0 export | - 554Gbps | 275.9 - 276 | 5.0 | | | | | | | | | | | | | | | _ |
| Table: DC24 (are: ingress | (ogress) | 1 | gress (Gb) | s) | - | Egress | (Gb/s) | | Total Gib/s / | L bandwidth | She Vik | N (Gb/s) | DATADISH | DATADISK | HL-LHC MIN | Ingress | Egress | increas | ed ingress | (Gb/b) | inject | ted egress | (Gb/s) | 50300 | Deletions | Space (TB) | To chateno |
| Sile | Cloud | TO-+TD | T1-→T0 | T2→T0 | TO exp. | TO-+TO | rot1 ne | T0-+T2 | S ingress | > egress | Total | ATLAS frac | CON [THI | THE [TH] | (agaess) | PCT6358 | 18creace | T0-→T0 | T1→T0 | T2→T0 | T0-→T0 | T0-+T1 | T0.→T2 | Tecon | pernour | (Sereeser of | factor |
| The cases | CERN | 24.4 | 30.3 | 27.9 | 204 | 24.4 | 00.2 | 66.7 | 01.7 | 303.1 | 2100 | 211 | 23101 | 204 | 270 | 3.5 | 9.7 | 13.00 | 25.50 | 20.76 | 13.00 | 200.04 | 00.30 | 072 | 9063 | 672 (100) | 0.9 |
| T05 (%) | - | 275 | 43% | 30% | 100 | 75 | 1004 | 180 | 1 | 302.1 | 2100 | | 13101 | 104 | 110 | | | | | | | | | | | | |
| 102(4) | - | 1.10 | 47.5 | 5070 | | 9 7.9 | 10.0 | 100 | 3 | | | | | | | | | | | | | | | | | | |
| Table: DC24 | | | Ingress | (8:60) | | E) | ress (Obh | 5) | Total Ob/S I | 5 bandwidth | Stie WAT | N (03/5) | DATACISH | DATADISK | HLUHC min | Ingress | Ecress | Increase | ed ingress | (01/5) | Inject | led egress | (08/5) | Space | Deletions | Space (TR) | T1 challeng |
| Sile | Cloud | TO exp. | T0→T1 ne | $T1 \rightarrow T1$ | T2→T1 | T1→T0 | $T1 \rightarrow T1$ | T1→T2 | Σ ingress | E egress | 70(2) | ATLAS 110 | size [TB] | free [TB] | (nåegrose) | Increase | Increase | T0-+T1 | T1-+T1 | T2-+T1 | T1-→T0 | T1-+T1 | T1→T2 | TB/24h | per hour | (deletions)h) | logress facts |
| NLATLAS | US. | 51.6 | 5.4 | 25.4 | 15. | 1 5.0 | 45.3 | | 106.5 | 120.0 | 400 | 400 | 29915 | 4257 | | 6.1 | 4.5 | 55.27 | 19.53 | 12.65 | 6.73 | 35.71 | 49.90 | 954 | 13060 | 954 (14k) | 0.5 |
| 1KLC62 | DE | 25.2 | 6.5 | 33.5 | 19. | 5 5.0 | 30.0 | | 55.3 | 64.0 | 400 | 162 | 16750 | 2550 | | 5.5 | 5.2 | 30.90 | 25.29 | 14.45 | 3.09 | 24.00 | 23.53 | 700 | 10751 | 755 (11k) | 5.4 |
| 2P3-CC | FR | 26.9 | 6.1 | 27.2 | 20. | 3 4.5 | 25.0 | 35.5 | 50.5 | 00.0 | 200 | 93 | 15532 | 2515 | | 5.5 | 4.4 | 31.50 | 19.96 | 14.53 | 3.09 | 19.63 | 25.31 | 702 | \$960 | 702 (10k) | 5.4 |
| EN.T1 | IT | 18,7 | 5.3 | 15.9 | 12 | 1 3.2 | 20.7 | | 54.0 | 45.0 | 200 | 51 | 9415 | 299 | | 6.2 | 5.6 | 23.23 | 12.15 | 9.64 | | 95.70 | 20,13 | 455 | 6503 | 455 (7k) | 7.9 |
| 0012414 | ND | 4.3 | 11.7 | 34.7 | 25. | 5 3.2 | 90.6 | 16.1 | 76.5 | 32.0 | 200 | 167 | 23335 | 2920 | 10 | 4.6 | 1.5 | 14.34 | 26.29 | 19.40 | 1.08 | 2.01 | 6.00 | 634 | 5014 | 634 (Sk) | 0.6 |
| ADA MATERS | NL | 10.5 | 4.5 | 22.5 | 16. | 0 2.0 | 13.4 | 14.3 | 53.5 | 30.0 | 400 | 201 | 0100 | 400 | 10 | 5.7 | 4.4 | 14.35 | \$5.47 | 12.13 | 1.01 | 90.00 | 11.22 | 474 | 6747 | 474 (7k) | 0.6 |
| 1 | E0 | 10.7 | 2.3 | 8.2 | 7. | 9 1.4 | 0.0 | 14.7 | 28.7 | 28.0 | 200 | 00 | 4900 | 100 | - 15 | 0.0 | 0.4 | 12.67 | 6.30 | 0.00 | 1.90 | 8.01 | 12.75 | 200 | 3603 | 250 (40) | 0.1 |
| Parasold | UN | 02.0 | 0.4 | 32.0 | 10 | 1 63 | - 24.7 | | 07.0 | rd.0 | +00 | -00 | 20070 | 4/27 | 35 | 4.0 | 3.2 | 7.80 | 12.52 | 12.10 | 0.00 | 21.00 | 0.30 | /32 | 10400 | 130,000 | 4.2 |
| RUNFLCOZ | 64 | 27.4 | 2.0 | 17.5 | 1 12 | | 23 * | | 00.1 | 00.0 | 100 | 100 | 13000 | 940 | | 1.0 | 10.0 | 29.45 | 12.77 | 8.33 | 4,91 | 20.44 | 24 *** | 500 | 1020 | 543 (75) | 14.0 |
| T15 (892) | 1 1 | 214.5 | 55.2 | 224.7 | 152 | 3 39.3 | 224.7 | 276.0 | 047.5 | 540.0 | 2500 | 1045 | 145451 | 21350 | 270 | ave 5.9 | ave 5.1 | 200.00 | 154 50 | 112.42 | 29.35 | 151.91 | 213.75 | 0070 | 20724 | 5676 (\$1k) | ava 6.9 |
| T1s (%) | - | 335 | 12 | 35% | 241 | 7% | 42% | 51% | | 5 Al T11 | 12 egress 27 | 6.0Gops of | hould match | T1-T2 inc | ress 275.9Gb | ps in the re | at table the | ning by T2 | correction t | lactor) | | | - | 0010 | | | |
| | - | | | | | - | | | | | | | | | | | | | | | | | - | | | | |
| Table: DC24 | | Nucleum | 1 | gress (Gb | (K) | 6 | ress (Go) | 6) | Total Gib/s | 5 bandwidth | Sile Via | N (GD/S) | DATADISK | DATADION | Use site | Ingress | Egress | Increase | ed ingress | (G2/5) | Inject | ted egress | (Gale) | 50300 | Deletions | Space (TB) | T2 challeng |
| Sibe | Cloud | | T0T2 | T1-+T2 | T2-+T2 | T2-+T0 | T2-+T1 | 12-12 | 2 ingress | Sectors | Total | ATLAS TRO | size [TB] | nee (TB) | 10/ DC24 | TICTERSO | 100/ease | T0:+T2 | T1-+T2 | 12-172 | T2T0 | T2-+T1 | 12-12 | 18/24h | perhour | 1066011570 | mpr. facto |
| VICTORIA WESTGRID T2 | CA | | 0.2 | 1.4 | 2 | 0 0.1 | 0.5 | 0.5 | 2.5 | 1.5 | 100 | 100 | 1907 | 1262 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (0k) | 0.0 |
| INTERNATIAS | CA | - | 0.0 | 0.1 | 0. | 0.0 | 0.2 | 0.2 | 0.1 | 0.4 | 20 | 20 | 1275 | 1150 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (0k) | 0.0 |
| WATERLOD-T2 | CA | - | 0.1 | 0.5 | 0. | 7 0.1 | 0.4 | 0.7 | 1.3 | 12 | 40 | 40 | 2100 | 1555 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0 | 0 (00) | 0.0 |
| a opro-12 | CA . | TRUE | 0.5 | 2.0 | 1 | 0.0 | 1.0 | 3.0 | 3.0 | 0.7 | 100 | 100 | 4000 | 370 | PALOE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0 | 0 1010 | 0.0 |
| SUSCEP. | UE | TRUE | 5.0 | 11.0 | 0. | 3 1.0 | 0.2 | 0.3 | 24.1 | 13.0 | 100 | 100 | 3730 | 210 | EALSE | 0.7 | 0.7 | 2.12 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 200 | 2010 | 209 (90) | 1.5 |
| routsiand | 05 | TRUE | 1.0 | 4.5 | 1 | 0 0.0 | 2.5 | 2.7 | 10.4 | 0.4 | | | 2022 | 110 | TRUE | 3.0 | 2.0 | 1.02 | 3.75 | 2.60 | 0.93 | 1.03 | 2.84 | 70 | 1110 | 79./160 | 2.2 |
| CV 2N | 06 | TRUE | 2.0 | 0.0 | 1 7 | 0.2 | 4.7 | 7.0 | 20.2 | 12.4 | 10 | | 2250 | 322 | TRUE | 5.9 | 0.4 | 9.95 | A 04 | 5.91 | 0.55 | 3.94 | 5.91 | 173 | 2460 | 172/260 | 7.9 |
| CV MI | 06 | TRUE | 10 | 47 | | 0.4 | 2.5 | 2.2 | 50.2 | | 10 | 10 | 2500 | 542 | TRUE | 19 | 2.5 | 0.62 | 244 | 1.75 | 0.24 | 1.45 | 6.24 | 51 | 719 | 51/16 | 2.5 |
| V.FREIBURG | 05 | TRUE | 0.2 | 0.7 | 0 | 0 0.1 | 0.5 | 0.5 | 1.5 | 1.7 | | | 2900 | 204 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | | 0 | 0.000 | 0.0 |
| FRONET LCG2 | 05 | | 0.1 | 0.7 | 0. | 0.1 | 0.5 | 0.7 | 17 | 12 | 10 | 10 | 1212 | 1120 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0.000 | 0.0 |
| and and | 00 | | 0.3 | 1.5 | 1 | 5 0.1 | 0.4 | 0.7 | 2.3 | 1.2 | | | 2650 | 1500 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (0k) | 0.0 |
| TOAC-Koste | 05 | | 0.0 | 0.4 | 0. | 3 0.0 | 0.1 | 0.3 | 0.5 | 0.4 | | - | 1133 | 747 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| 25LMU | 30 | TRUE | 0.1 | 0.7 | 0. | 7 0.1 | 0.7 | 1.0 | 1.0 | 1.0 | | | 2701 | 145 | FALSE | 1.0 | 1.0 | | 0.00 | 0.00 | | | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| 305-1002 | DE | TRUE | 0.3 | 1.0 | 1. | 7 0.2 | 1.2 | 1.7 | 3.0 | 3.0 | | | 4725 | 630 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| WPIN-UNIBA | DE | | 0.0 | 0.8 | 0. | 4 0.0 | 0.2 | 0.2 | 0.7 | 0.5 | | | 1128 | 740 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| AUPA | 68 | | 0.0 | 0.4 | 0. | 2 0.0 | 0.3 | 0.6 | 0.0 | 0.9 | 9 | 9 | 250 | 52 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (0K) | 0.0 |
| MLC62 | ES | TRUE | 0.0 | 2.3 | 1. | 5 0.3 | 0.9 | 1.5 | 4.5 | 2.9 | 10 | 10 | 1566 | - 243 | TRUE | . 9.3 | 6.5 | 0.55 | 2.14 | 1.53 | | 0.72 | 5.53 | 45 | 635 | 45 (1k) | 7.3 |
| 2 | 63 | | 0.1 | 0.5 | 0 | 7 0.1 | 0.2 | 0.4 | 1.6 | 0.7 | 200 | 200 | 800 | 212 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (0k) | 0.0 |
| CG-INGRID-PT | 63 | | 0.0 | 0.1 | 0. | 2 0.0 | 0.1 | 0.2 | 0.4 | 0.2 | 9 | | 500 | 354 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (0k) | 0.0 |
| 0.1002 | 60 | TRUE | 0.2 | 1.0 | 1. | 2 0.1 | 0.5 | 1.1 | 2.5 | 2.0 | | | 3400 | 239 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0 | 0 (0k) | 0.0 |
| DA-OTFOR | 60 | | 0.0 | 0.1 | 0. | 1 0.0 | 0.1 | 0.2 | 0.1 | 0.5 | 10 | 10 | 300 | 140 | PALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (00) | 0.0 |
| O OT MELLER | 100 | TRUE | | 20.9 | 10 | 1 24 | 13.5 | 34.1 | 41.0 | 29.0 | 40 | 40 | 7,000 | 1207 | THUE | 4.5 | 0.4 | 1.55 | 12.00 | 11.04 | 2.02 | 10.70 | 1.04 | 335 | +c03 | 330 (50) | 0.0 |
| UNSJ C62 | 58 | HUE | 0.0 | 13.0 | 10. | 0.0 | 0.1 | 10.2 | 21.0 | 0.0 | 100 | 100 | 3004 | 700 | FALSE | 10.2 | 10 | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 200 | 5100 | 0,000 | 1.0 |
| 0.092 | FR | | 0.0 | 0.1 | 0 | 0 00 | 0.1 | 0.0 | 0.0 | 0.3 | | 20 | 840 | 333 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0 | 0.000 | 0.0 |
| RIF | FR | | 0.4 | 2.0 | 1 1 | 7 0.2 | 1.9 | 2.6 | 41 | 42 | 100 | 100 | 6000 | 4305 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0 | 0 (06) | 0.0 |
| 2P2-LP0 | FR | | 2.5 | 9.4 | 7. | 2 0.7 | 3.5 | 7.2 | 19.1 | 11.3 | 100 | 100 | 2564 | 1509 | TRUE | 11.0 | 7.7 | 2.39 | 5.76 | 6.25 | 0.55 | 2.56 | 6.25 | 154 | 2014 | 154 (3k) | 7.3 |
| 2PS-LAPP | FR | TRUE | 2.6 | 90.0 | 0 | 1 1.2 | 4.6 | 7.5 | 20.9 | 12.6 | 20 | 20 | 6000 | 2504 | TRUE | 6.2 | 5.0 | 2.41 | 6.54 | 6.34 | | 3.54 | 0.34 | 105 | 2635 | 155 (2k) | 6.4 |
| OPD-CREM | FR | TRUE | 1.4 | 5.1 | 4 | 1 0.5 | 2.7 | 4.1 | 10.5 | 7.5 | 100 | 100 | 2232 | 135 | TRUE | 6.0 | 4.4 | 1.20 | 4.51 | 9.23 | | 2.00 | 3.23 | 95 | 1247 | 95 (1k) | 4.2 |
| IN MILANO ATLASC | IT | | 0.1 | 0.5 | 0. | 0.1 | 0.0 | 1.0 | 1.2 | 1.7 | 10 | 10 | 1907 | 1407 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| IN MARCELATERS | п | TRUE | 3.1 | 11.0 | 0. | 0.0 | 0.4 | 0.0 | 23.2 | 54.0 | 100 | 100 | 4004 | 342 | TRUE | 9.2 | 6.7 | 2.03 | 10.30 | 7.45 | | 4.45 | 7.45 | 210 | 3100 | 215 (30) | 7.3 |
| PN-ROMA1 | IT | TRUE | 1.4 | 5.1 | 4 | 0 0.4 | 2.4 | 3.5 | 10.5 | 0.0 | 10 | 10 | 1584 | 342 | TRUE | 0.0 | 0.0 | 1.22 | 4.40 | 3.20 | 0.34 | 1.57 | 3.20 | 54 | 1331 | 54 (1k) | 0.5 |
| FN-FRASCATI | IT | | 0.1 | 0.7 | 1 0 | 0.1 | 0.4 | 0.0 | 1.5 | 1.0 | 10 | 10 | 1979 | 1301 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| -SNIC-T2 | ND | | 0.0 | 0.0 | 0. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | - | 0 | 0 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| VIRE-LHEP | ND | | 0.0 | 0.0 | 0. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | 0 | 0 | FALSE | 1.0 | 1.0 | 0.00 | 010 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (0K) | 0.0 |
| Her-aurrod (to tape) | NL | PRAVDA | 0.3 | 2.0 | 1 1 | 0.2 | 1.9 | 1.6 | 37 | 2.1 | 1000 | 1000 | 3550 | 263 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| CONTRACTOR OF THE OWNER | NL. | | 0.2 | 1.0 | 1. | 0.1 | 0.5 | 0.5 | 2.5 | 15 | | | 2675 | 1917 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | 0 (96) | 0.0 |
| ELCO2 | NL | | 0.0 | 0.1 | 0 | 0.1 | 0.5 | 0.0 | 0.2 | 0.0 | 100 | 100 | 100 | 010 | EALOF | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | | 0,000 | 0.0 |
| LPortugation (1987) | 1 102 | | 0.1 | 0.4 | 0 | 1 10 | 0.0 | 0.4 | 11 | 0.0 | .00 | .00 | 120 | | FALDE | 1.0 | 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0~ | 0~ | 0 | - | 0.000 | 0.5 |
| CUTZ.RHUE | UK | | 0.0 | 0.7 | | 0.0 | 0.1 | 0.2 | 0.0 | 0.5 | 10 | 10 | | | FAIRE | 1.0 | 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | | 0.000 | 0.0 |
| INORTHORID MAN HER | UK | TRUE | 3.4 | 13.5 | 10 | 8 1.5 | 7.0 | 8.2 | 20.0 | 15.5 | 40 | 40 | 4945 | 420 | TRUE | 54 | 0.0 | 3,00 | 11,00 | 7.85 | 1.00 | 0.04 | 7.50 | 23.5 | 325.5 | 231 (36) | 73 |
| KLSOUTHORID.RALPP | UK | | 0.0 | 0.2 | 0. | 4 0.0 | 0.2 | 0.4 | 0.0 | 0.0 | 20 | 20 | 700 | 445 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| CLSCOTGRID-GLASGOW | UK | | 0.2 | 0.6 | 0. | 0.1 | 0.5 | 0.5 | 1.0 | 1.8 | 20 | 20 | 4500 | 3599 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| GLT2-OMUL | UK | | 0.4 | 2.2 | 2 | 0.2 | 1.3 | 1.4 | 5.0 | 2.9 | | | 9000 | 6731 | FALSE | 1.0 | 1.0 | 0.00 | 010 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (06) | 0.0 |
| CLOCOTORID-ECDF | UK | | 0.0 | 0.2 | 0. | 2 0.0 | 0.2 | 0.3 | 0.5 | 0.5 | | | 0 | 0 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (04) | 0.0 |
| CINORTHORID LANCE HEL | UK | | 0.4 | 1.5 | 1. | 0.0 | 1.3 | 2.5 | 2.5 | 4.4 | 40 | 40 | 5000 | 3610 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (0k) | 0.0 |
| CINORTHORID-LIVIER | UK | | 0.0 | 0.2 | 0. | 3 0.0 | 0.1 | 0.2 | 0.5 | 0.4 | | | 440 | 987 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| Iwan-LCO2 (no tape) | TW | | 0.2 | 1.2 | 1. | 2 0.1 | 0.0 | 1.1 | 2.0 | 1.7 | 20 | 20 | 7477 | 0200 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| | 1.10 | | 0.0 | 0.0 | 0. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10 | 10 | 7240 | 7103 | FALSE | 1.0 | 1.0 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0 | 0 | 0 (010 | 0.0 |
| 472 | ~~~ | | | | | | | | | | _ | | _ | _ | | | | | | _ | | | | | | | |
| WTZ-CH8 | US | TRUE | 11.5 | 45.0 | 32 | 0 4.2 | 22.1 | 34.4 | 88.7 | 00.7 | 100 | 100 | 11700 | 2015 | TRUE | 13.7 | 7.2 | 11.25 | 41.35 | 28.64 | 3.00 | 15.80 | 28.64 | 363 | 12340 | 365 (1293 | 7.3 |
| 12 /12.CHB 412 | US US | TRUE | 11.5 | 45.0 | 32 | 0 42 | 22.1 | 34.4 | 88.7 | 00.7 49.3 | 100 | 100 | 11700 | 2015 | TRUE | 13.7 | 7.2 | 11.25 | 41.35 | 28.64 | 3.00 | 15.80 | 28.64 | 000 | 12340 | 000 (129) 004 (10K) | 7. |

7 PB

6 PB

5 PE

4 PE

3 PB

2 PI

1 PF

07/0

ATLAS Data Flows & Rucio :: Mario Lassnig

RAW

12/16

12/01

17

12/16

12/01

ATLAS has cloud R&D projects ongoing with Amazon, Google, and SEAL Storage

Integration into ADC systems PanDA & Rucio, and in turn FTS, GFAL, Davix Very close development collaboration across the full stack

Two major angles to consider when discussing clouds

Technical Access tools, transfer protocols, monitoring, authn/z, accounting, billing, storage, ... Deployed on-site or off-site Organisational Centralised or distributed Public (institute, laboratory, ...) or commercial In-kind contribution or paid service

Large development programme in front of us to make cloud storage viable

Throughput control, access control, peering control, cloud transfer tool control, lifetime control, cost control,

11/0

10/1

Cloud

Data stored at the Google RSE Daily egress traffic out of the Google RSE 350 TB — AOD RDO 300 TB 250 TB DAOD log 200 TB EVN1 use 150 TB ESD

100 TB

50 TE

0 B

07/01

07/16

08/1

09/01

09/1/

10/01

10/16

11/01

11/16



aws





Summary



Rucio is working great for ATLAS!

Thanks to the dedication of a great team We are happy and grateful for this big community

The ATLAS data needs are immense and continuously increasing

Data flow complexity, incl. system topology and experiment policies Throughput and file rates are ever increasing Crazy R&D projects to keep things interesting ;-)



ATLAS will continue to contribute to the development and support of Rucio into the HL-LHC era!

