Efficiently Backing up Terabytes of Data with pgBackRest

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Crunchy Data

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Agenda

1. Why Backup?
2. Living Backups
3. Design
4. Features
5. Performance
6. Demonstration
7. Questions?
Why Backup?

- Hardware Failure:
  - No amount of redundancy can prevent it.

- Replication:
  - WAL archive for when async streaming gets behind.
  - Sync replica from backup instead of master.

- Corruption:
  - Can be caused by hardware or software.
  - Detection is of course a challenge.
Why Backup?

- Accidents:
  - So you dropped a table?
  - Deleted your most important account?

- Development:
  - No more realistic data than production!
  - May not be practical due to size / privacy issues.

- Reporting:
  - Use backups to standup an independent reporting server.
  - Recover important data that was removed on purpose.
Schrödingers Backup

The state of any backup is unknown until a restore is attempted.
Making Backups Useful

- Find a way to use your backups
  - Syncing / New Replicas
  - Offline reporting
  - Offline data archiving
  - Development

- Unused code paths will not work when you need them unless they are tested
  - Regularly scheduled automated failover using backups to restore the old primary
  - Regularly scheduled disaster recovery (during a maintenance window if possible) to test restore techniques
Rsync powers many database backup solutions but it has some serious limitations:

- Single-process.
- One second timestamp resolution.
- Incremental backups require previous backup to be uncompressed.

pgBackRest does not use rsync, tar or other typical backup tools:

- Protocol supports local/remote operation.
- Solves timestamp resolution issue.
Multi-Process Backup & Restore

- Compression is usual bottleneck:
  - But most PostgreSQL backup solutions are single-process.
  - pgBackRest solves the problem with multi-processing.
  - 1TB/hr raw throughput even on a 1Gb/s link using multiple cores.
Local or Remote Operation

- Custom protocol allows backup, restore, and archive locally or remotely via SSH with minimal configuration.
- No direct access to PostgreSQL is required from the remote server which enhances security.
Multiple backup types:

- Full
- Differential
- Incremental

pgBackRest is not susceptible to the time resolution issues of rsync, making differential and incremental backups safe.
Backup Rotation & Archive Expiration

- Retention Based on full or differential backups.
- WAL retention for all backups or configure number of recent backups.
- WAL required for consistency of backups always preserved.
Backup Integrity

- Checksums are calculated for every file in the backup and rechecked during a restore.
- After a backup required WAL segments are checked in the repository.
- Simple backup format:
  - Backup directories have the same format as a PostgreSQL cluster.
  - Clusters can be brought up in place with snapshots if compression is disabled.
  - Advantageous for terabyte-scale databases.
- All operations utilize file and directory level fsync to ensure durability.
Backup Resume

- An aborted backup can be resumed from the point where it stopped.
- Checksumming files on resume takes place on the backup server.
- Saves load on the master by not compressing and transmitting resumed files.
Compression and checksum calculations are performed in stream.

Compression is not done more than once.

Lower compression is used when the destination is uncompressed to efficiently utilize CPU and network bandwidth.
Delta Restore

- Backup manifest contains checksum and size for every file.
- On delta restore all files not present in the backup or with a different size are removed from PGDATA.
- The remaining files are checksummed and only files with a checksum mismatch are restored.
- Multi-processing can lead to dramatic reductions in restore time and network utilization.
Advanced Archiving

- Dedicated commands are included for both pushing WAL to the archive and retrieving WAL from the archive.
- Push command automatically detects WAL segments that are pushed multiple times and de-duplicates when the segment is identical, otherwise an error is raised.
- Push and get commands both ensure that the database and repository match by comparing PostgreSQL versions and system identifiers to prevent misconfiguration.
- Asynchronous archiving allows compression and transfer to be offloaded to another process which maintains a continuous connection to the remote server, improving throughput significantly.
  - Critical feature for databases with extremely high write volume.
Tablespace & Link Support

- Tablespaces are fully supported and on restore tablespaces can be remapped to any location.
- Remap all tablespaces to one location with a single command which is useful for development restores.
- File and directory links are supported for any file or directory in the PostgreSQL cluster.
- Restore all links to their original locations, remap some or all links, or restore some or all links as normal files or directories within the cluster directory.
Selective Restore

- Restore only specified databases out of a cluster backup.
- Other files are restored as sparse, zeroed files to save space.
- All WAL must be replayed.
- Cannot connect to non-restored databases, can only drop them.
Backup from Standby

- Backup is started on master.
- Backup starts when replay location on standby reaches start backup location.
- Reduces load on master because replicated files are copied from the standby.
Compatibility with PostgreSQL $\geq 8.3$

- Support for versions down to 8.3, since older versions of PostgreSQL are still regularly utilized.
## Performance

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<thead>
<tr>
<th>Parameters</th>
<th>pgBackRest</th>
<th>rsync</th>
</tr>
</thead>
<tbody>
<tr>
<td>processes: 1</td>
<td>141 Seconds</td>
<td>124 Seconds (.13X Faster)</td>
</tr>
<tr>
<td>network compression: l3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>destination compression: none</td>
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<td></td>
</tr>
<tr>
<td>processes: 2</td>
<td>84 Seconds (1.48X Faster)</td>
<td>N/A</td>
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<td>network compression: l3</td>
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<tr>
<td>destination compression: none</td>
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<td></td>
</tr>
<tr>
<td>processes: 1</td>
<td>334 Seconds (1.52X Faster)</td>
<td>510 Seconds</td>
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<tr>
<td>network compression: l6</td>
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<tr>
<td>destination compression: l6</td>
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<tr>
<td>processes: 2</td>
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<tr>
<td>network compression: l6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>destination compression: l6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Demonstration

Live Demo — this should be fun!
Questions?

website: http://www.pgbackrest.org
email: david@pgbackrest.org
e-mail: david@crunchydata.com
releases: https://github.com/pgbackrest/pgbackrest/releases
slides & demo: https://github.com/dwsteele/conference/releases