# Distributed geoprocessing of streaming data for a 3D context aware visualisation solution of a wildfire scenario


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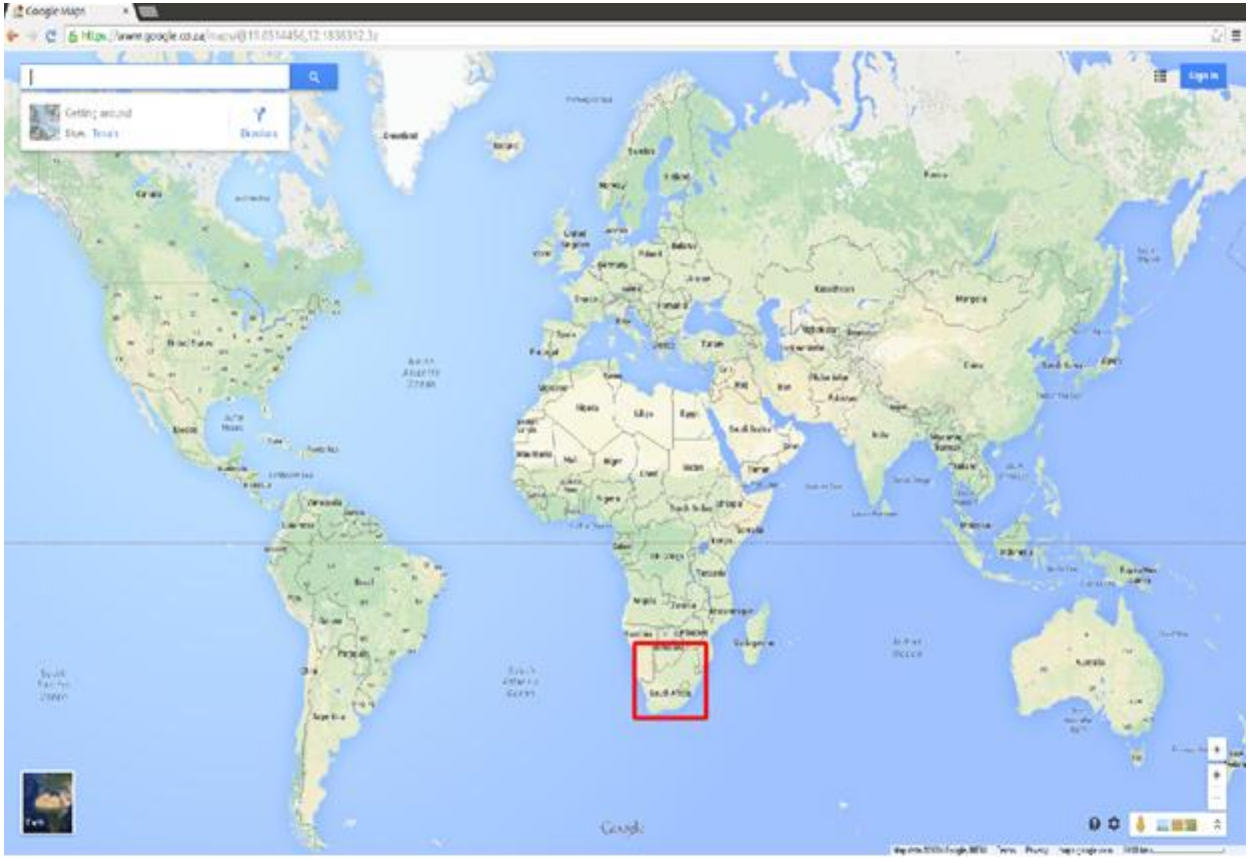
# Map – South Africa?



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# Wildfires

- Wildfire- Uncontrolled, area of combustible vegetation, occurs outside the boundaries of urban areas
- Requirements- Oxygen, fuel, heat
- Vegetation wildfires occur in most parts of the world
- In South Africa fires are used as a technique to manage the landscape
- Fires can easily get out of control
- This might lead to catastrophic incidents
- Incidents can be mitigated by the timely dissemination of notifications
- Notifications include information derived from earth observation data

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# Use case


- This research was inspired by an industry use case – AFIS
- AFIS – Advanced Fire Information System (developed by researchers at the CSIR Meraka Institute)
- Form of wildfire notifications:  SMS or e-mail
- Develop an alerting component of a wildfire geoprocessing system that adds a URL (that points to a 3D context visualisation of a wildfire) to a notification message.
- Alerting component should be optimized for rapid performance
- 3D visualisation-ready as soon as notification is disseminated
- This implies rapid geoprocessing for demand-time results to prevent backlogging

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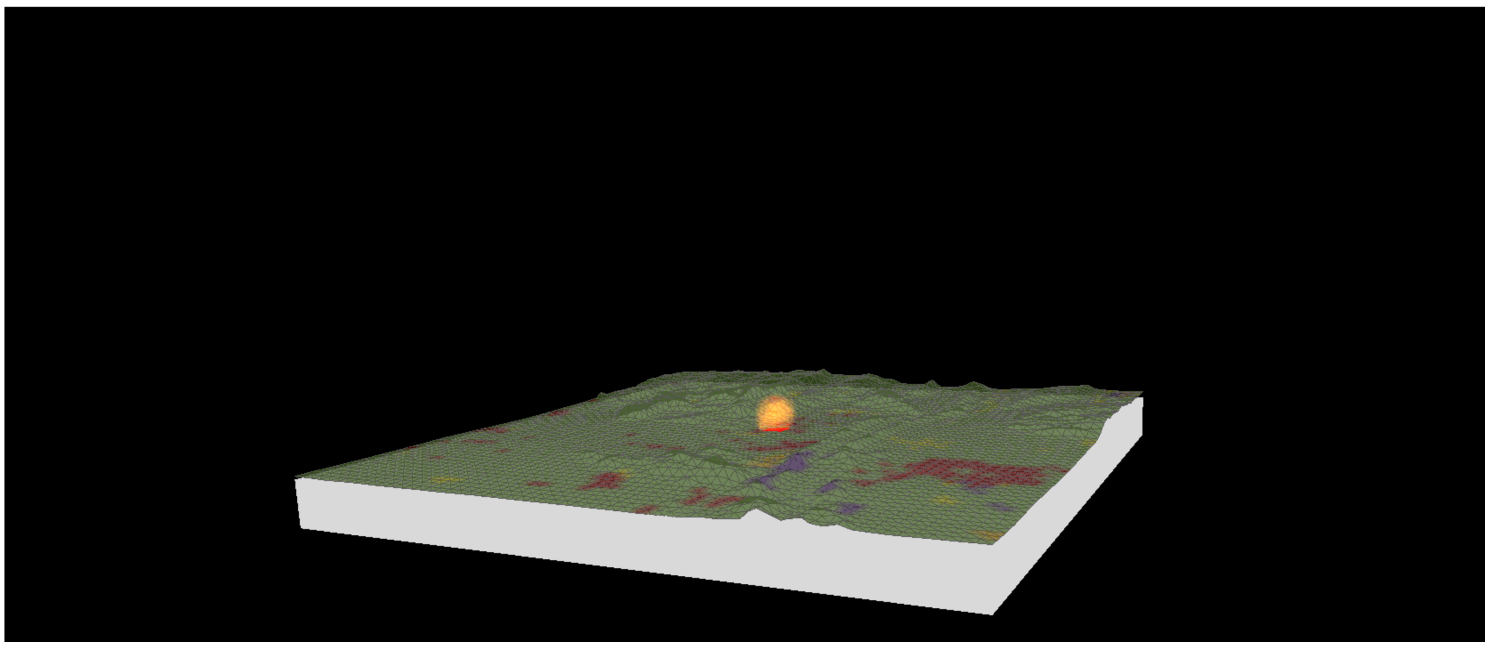
# Example 3D visualisation

```
Longitude: 27.510999999999999
Latitude: -24.541
Elevation: 1029
Fire Intensity: 42.5
Population (Per Grid, Squared): 0.0363893
Landcover: Natural - Woodland
Vegetation: Western Sandy Bushveld
```

- [ ] Vegetation
- [ ] Population
- [x] Land Cover

Degraded
Urban Built-Up
Cultivated
Natural
Mines
Waterbodies



**Included Data:**

- Elevation Data
- Vegetation Data
- Population Data
- Land Cover Data
- Infrastructure Data (planned)
- Wind Data (planned)

**Importance:**

- Indication of fire spread
- Terrain layout for emergency response
- Situational awareness

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# Aims and Objectives

- **Aim: Determine if Web Processing Services are effective for on-demand geoprocessing of intermittently high velocity streaming geospatial data for the purpose of generating 3D visualisations**
- **Objective 1: Determine how the geoprocessing chain should be constructed**
- **Objective 2: Implement the geoprocessing chain components using various libraries to determine the fastest implementation topology**
- **Objective 3: Determine the architectural style that delivers the fastest throughput. Loosely-coupled components (multiple events processed concurrently) or tightly-coupled components (single event processed one at a time)?**
- **Objective 4: Compare the two implementation styles with and without the use OGC WPSs**

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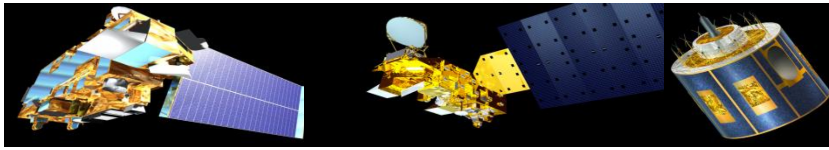
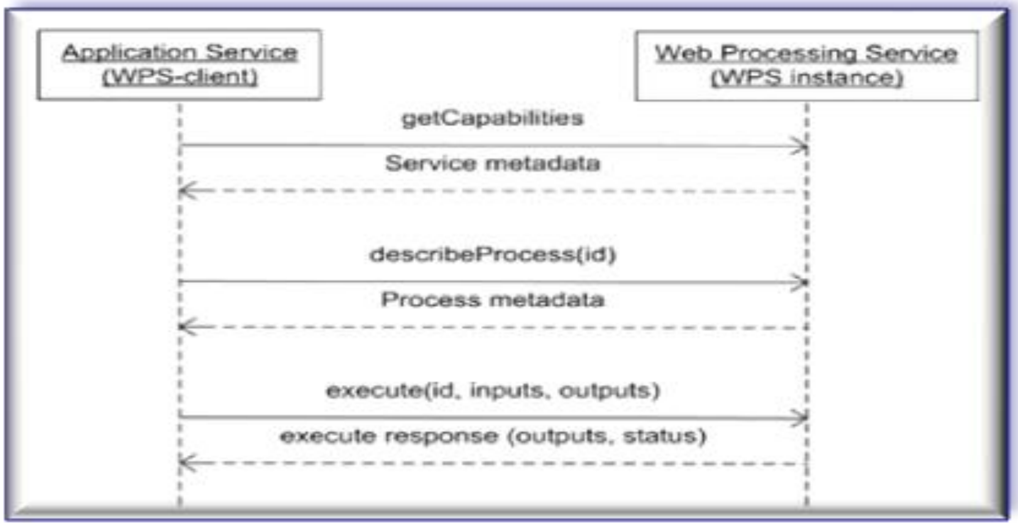
# Data



- Vegetation wildfires-intermittent data streams of geospatially referenced active fire detection events generated by earth observing satellites
- Geostationary:  ESA Meteosat 8 satellite - SEVIRI (Spinning Enhanced Visible and Infrared Imager).  Temporal resolution of 15 minutes.  Maximum number of fires per 15 minutes: 8362
- Polar-orbiting: NASA Terra and Aqua -  MODIS (Moderate Resolution Imaging Spectroradiometer).  Temporal resolution of 6 hours.   Maximum number of fires 6 hourly: 48 606
- SEVIRI data-lower spatial resolution than MODIS data
- MODIS data-include smaller fires than SEVIRI data
- We utilised MODIS and SEVIRI data because AFIS uses it
- Streams with a large number of fire events need to be processed rapidly in relation to large datasets of contextual variables
- Spatial filtering will decrease the number of fire events
- Nature of data: atomic messages

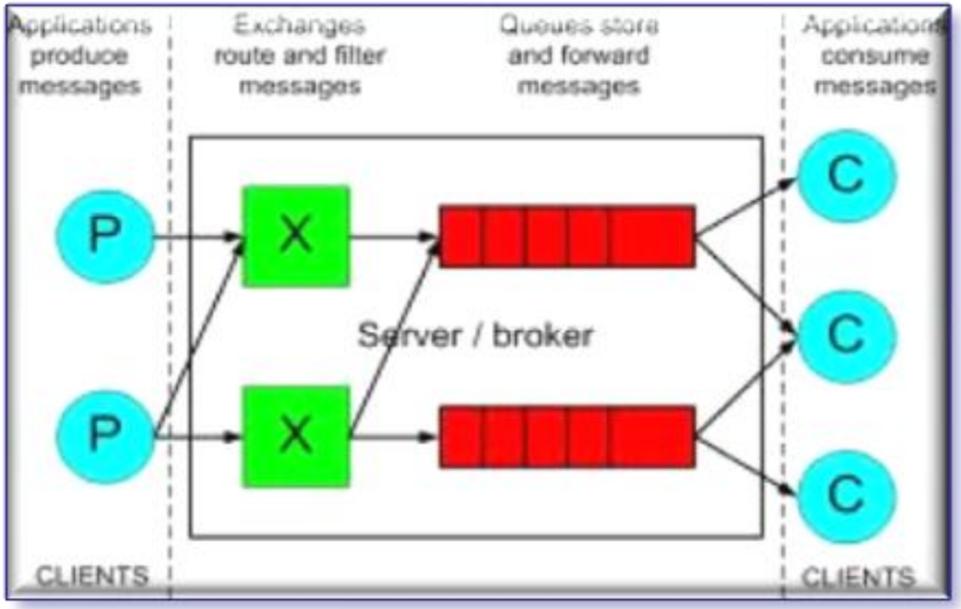
# Software components-Web Processing Services

- OGC Web Processing Service – Interface that provides rules on how requests and responses of arbitrary geoprocessing services should be constructed
  - Provides a mechanism to perform distributed web-based processing on geospatial data
  - Facilitates the discovery and publishing of geospatial processes
  - Encourages interoperability and software implementation abstraction
  - Can be chained to form workflows



# Software components – Advanced Message Queuing Protocol

- **Advanced Message Queuing Protocol enables applications to communicate over messaging middleware servers**
- **Components: producers, exchanges, queues and consumers**
- **Components are loosely coupled and allows for concurrency and distributed systems**

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# Methodology

1. **Determine the design of the geoprocessing chain**
2. **Implement the components of the geoprocessing chain in alternative ways to determine which style of the component offered the fastest throughput – best implementation**
3. **Set up OGC WPSs for each component of the geoprocessing chain using the best implementation**
4. **Set up the chaining of the OGC WPS components in a loosely-coupled style and in a tightly-coupled style**
5. **Repeat steps three and four without using OGC WPS components**
6. **Benchmark all of the combinations:**

   Tightly-coupled process chaining with OGC WPSs

   Tightly-coupled process chaining without WPS

   Loosely-coupled process chaining with OGC WPSs

   Loosely-coupled process chaining without WPSs

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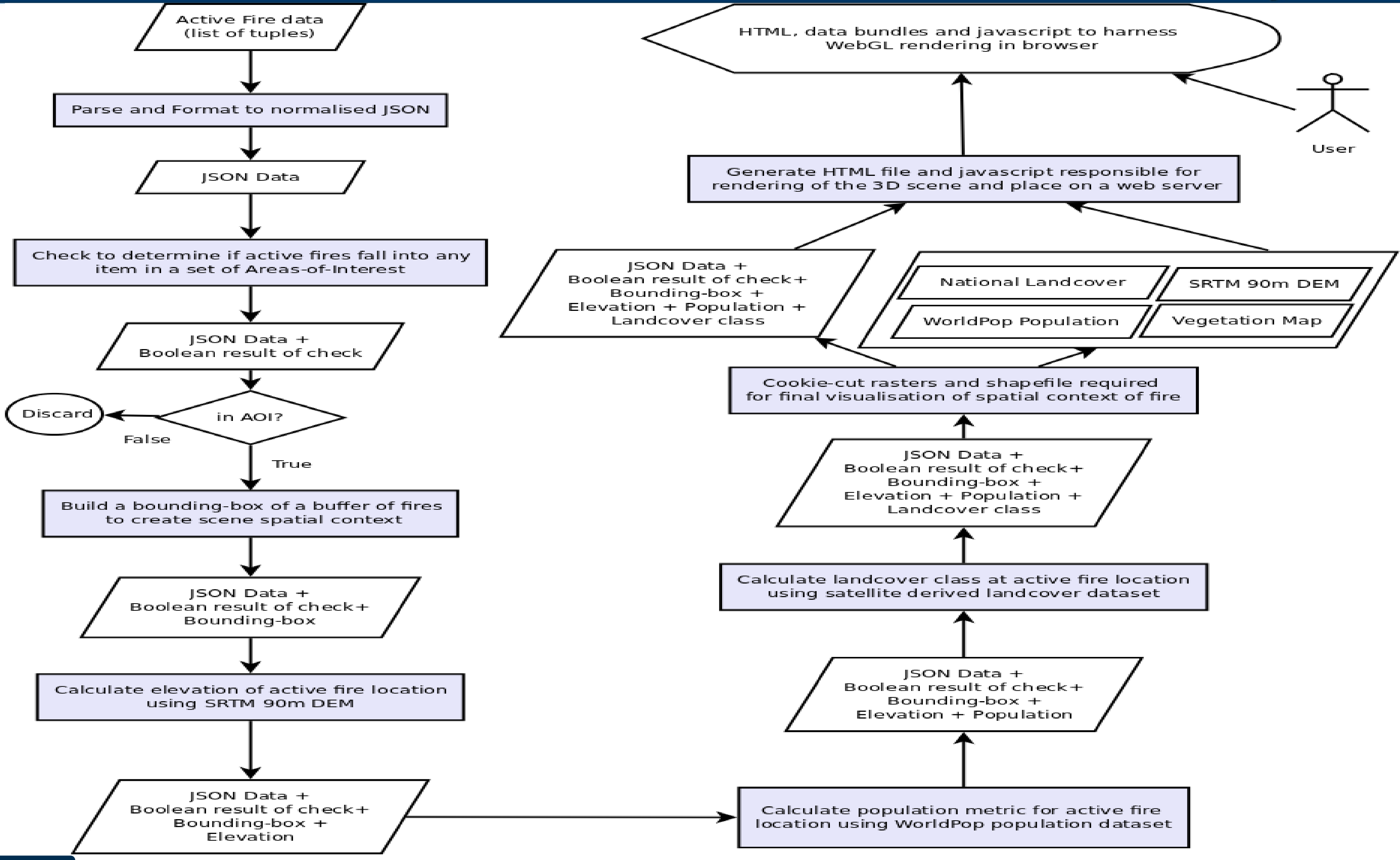
# Geoprocessing chain design



# Software Descriptions

- Rtree is a Python wrapper of libspatialindex that provides advanced spatial indexing features.
- Shapely is a Python package that manipulates and analyses planar geometric objects.
- OGR (Simple Features Library) is a library for reading and writing vector geospatial data formats.
- GDAL (Geospatial Data Abstraction Library) is a library for reading and writing raster geospatial data formats.
- PostGIS is a spatial database extender for the PostgreSQL object-relational database.

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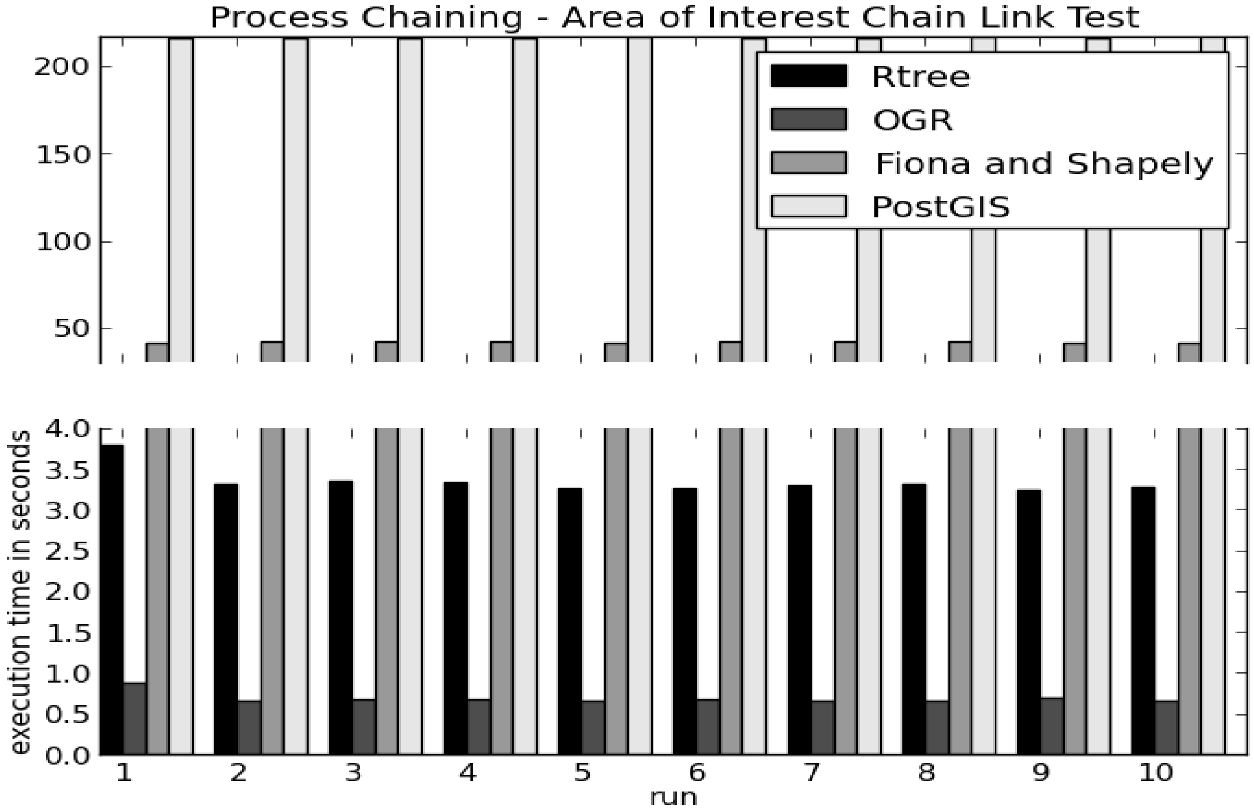
# Results-area of interest check test




**Determines if a fire falls within a region of interest**
**Indices or shapefiles – region of interest**
**Point – fire location**
**Point intersect with region – fire in area of interest**

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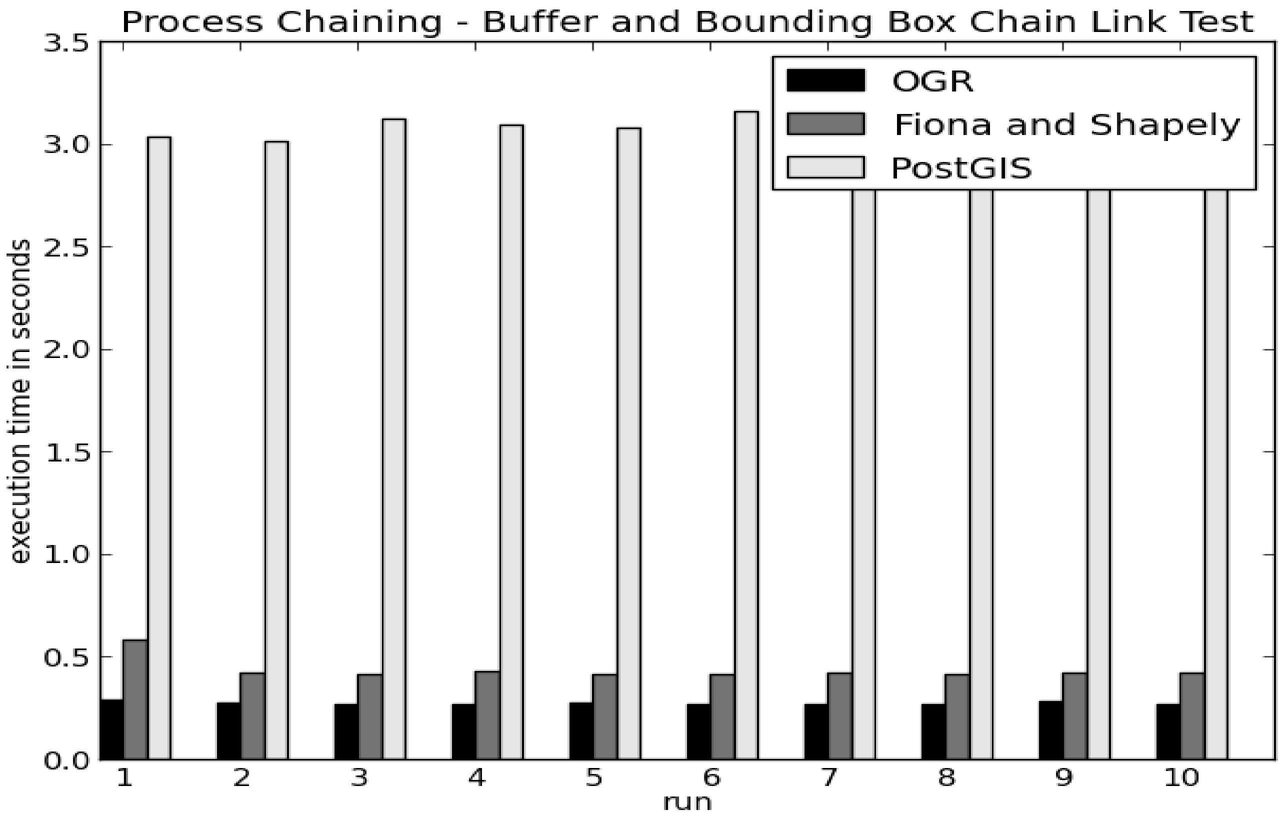
# Results-buffer and bounding box test




**Places a buffer around the fire and calculates its bounding box**
**Point – fire location**
**Buffer around point – area for cookie-cut**
**Bounding box of buffer - extent**

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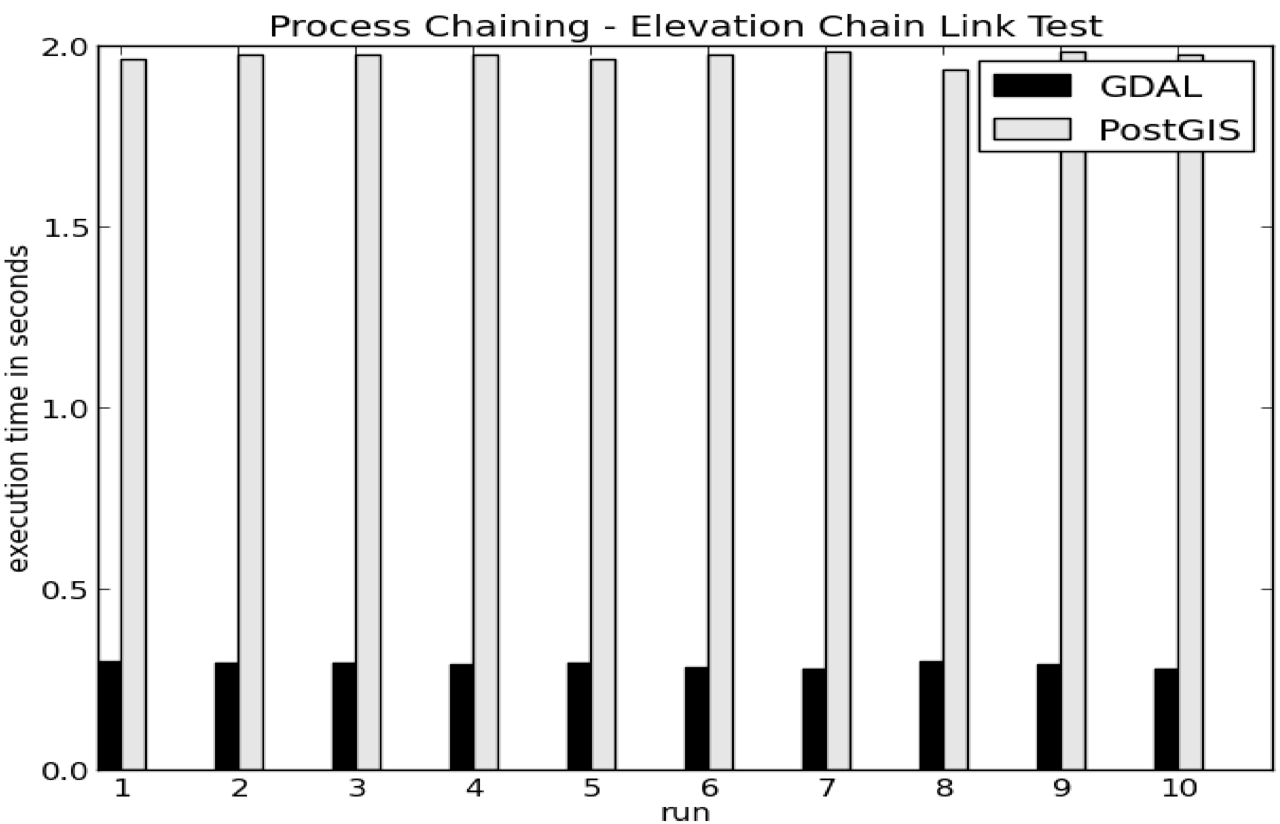
# Results-elevation calculation test




**Calculates elevation**
**Point – fire location**
**GeoTIFF – SRTM90m**
**Value at point on**
**GeoTIFF - elevation**

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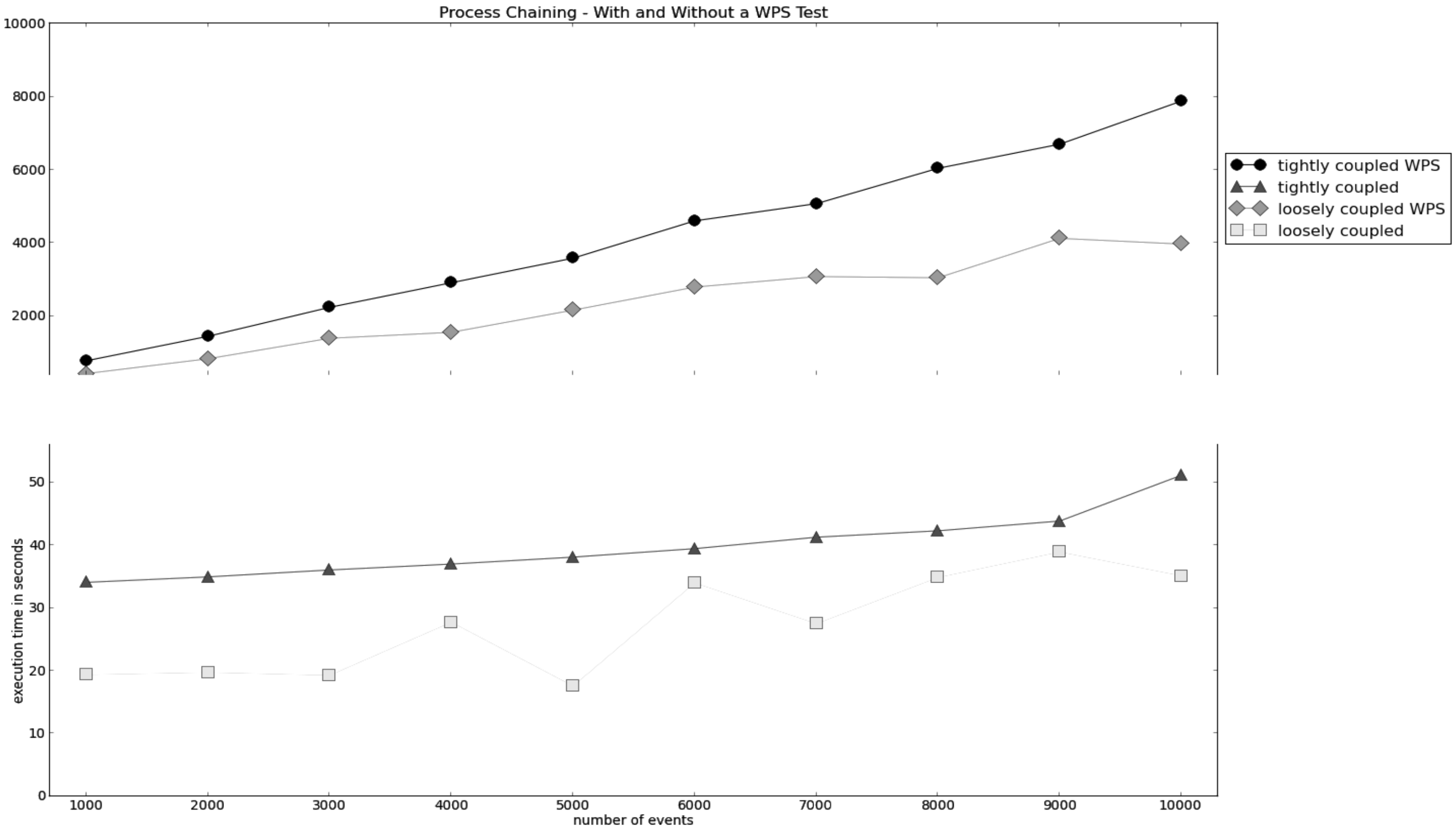
# Results-component chaining tests WPS versus no WPS




**Execution of entire geoprocessing chain: fire ingest to 3D visualisation generation**

**Tightly-coupled – nested method calls**

**Loosely-coupled – AMQP producers and consumers**

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# Discussion

- Rtree: Expected to perform the best because of spatial indexing
- Fiona plus Shapely and PostGIS:  Expected to outperform OGR due to the use of GEOS (Geometry Engine – Open Source)
- Rtree: Floating point comparisons
- Python OGR: Integer comparisons, C pointers
- Fiona & Shapely: Python objects
- PostGIS: Advanced indexing underperformed. It may be due to the nature of the data in that the data is atomic. Small pieces of data needs to be processed rapidly in relation to large datasets of contextual variables.  Bulk operations are preferred when using relational databases.  This was not the right fit due to the fact that a connection had to be created every time a new fire event had to be processed.
- Tightly-coupled component chaining performed worse than loosely-coupled component chaining (serial versus parallel)
- Geoprocessing with a WPS is slower than geoprocessing without a WPS
- Reasons:  WPS implementation itself? WPS invocation and destruction for every fire event

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# Conclusion

- Databases and Web Processing Services should not be used when dealing with atomic pieces of data and when demand-time results are required – slows down performance
- Loosely-coupled component chaining should be used – Workflows that are loosely-coupled provides a better throughput than workflows that are tightly-coupled
- High performance and/or distributed computing should be considered - Speeds up the throughput of the geoprocessing chain
- This research shows that demand-time results can be achieved when not using Web Processing Services and scaling horizontally (loosely-coupled component chaining)

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# Thank you...

# Questions?

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