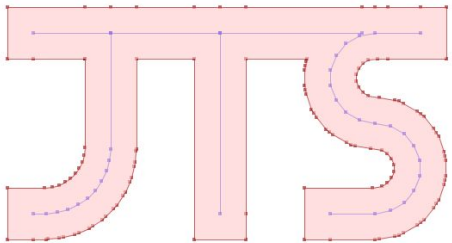


State of JTS

Presented by:
James, Jody, Rob, (Martin)

LocationTech

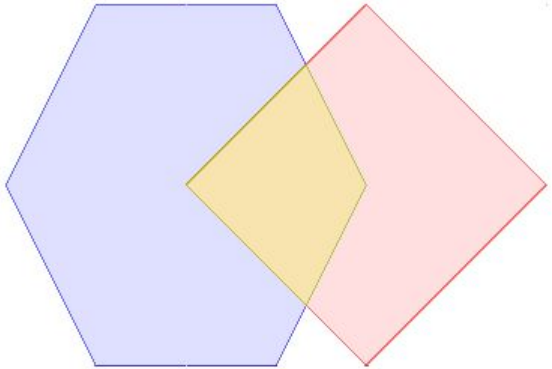
Welcome

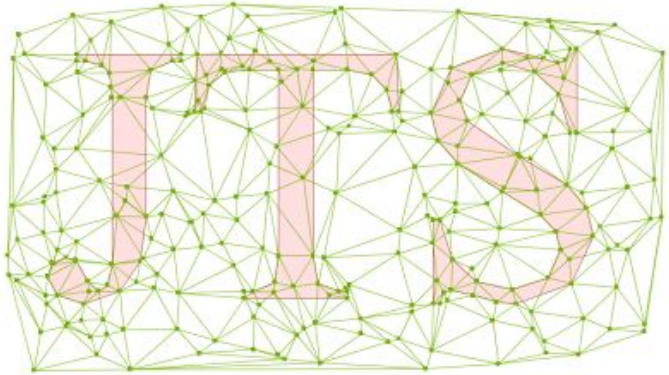
Martin Davis	James Hughes	Jody Garnett	Rob Emanuele
Vivid Solutions	CCRi	Boundless	Azavea

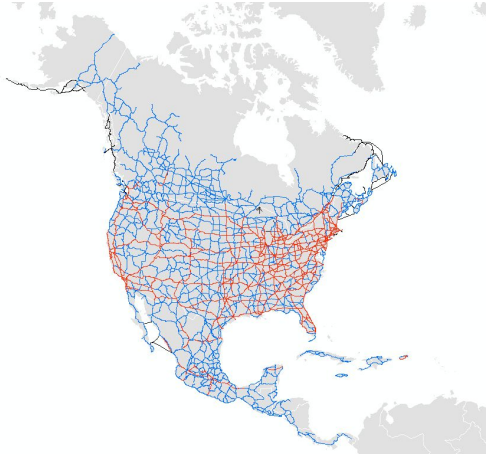
Introducing
JTS Topology Suite

What is JTS Topology Suite?

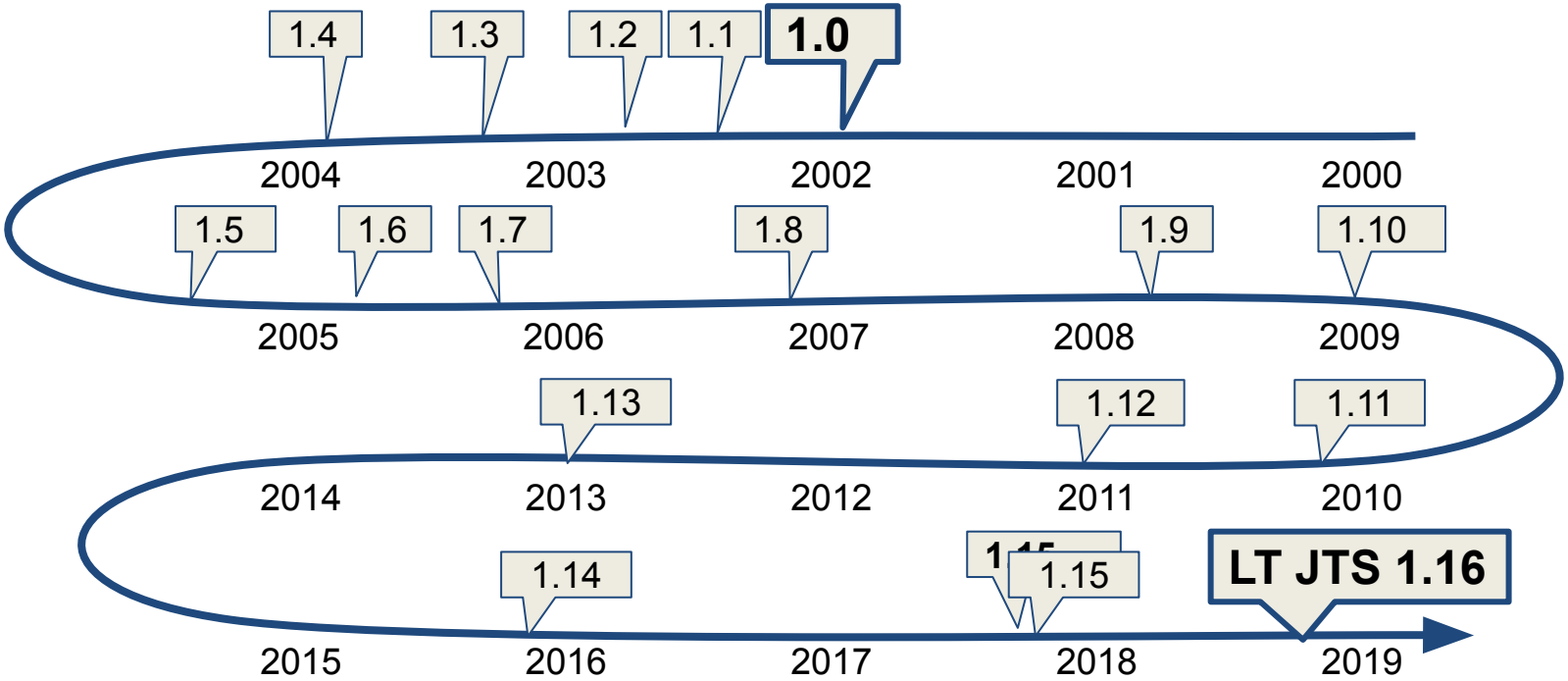
Java API for working with **2D Geometries**







JTS Project History



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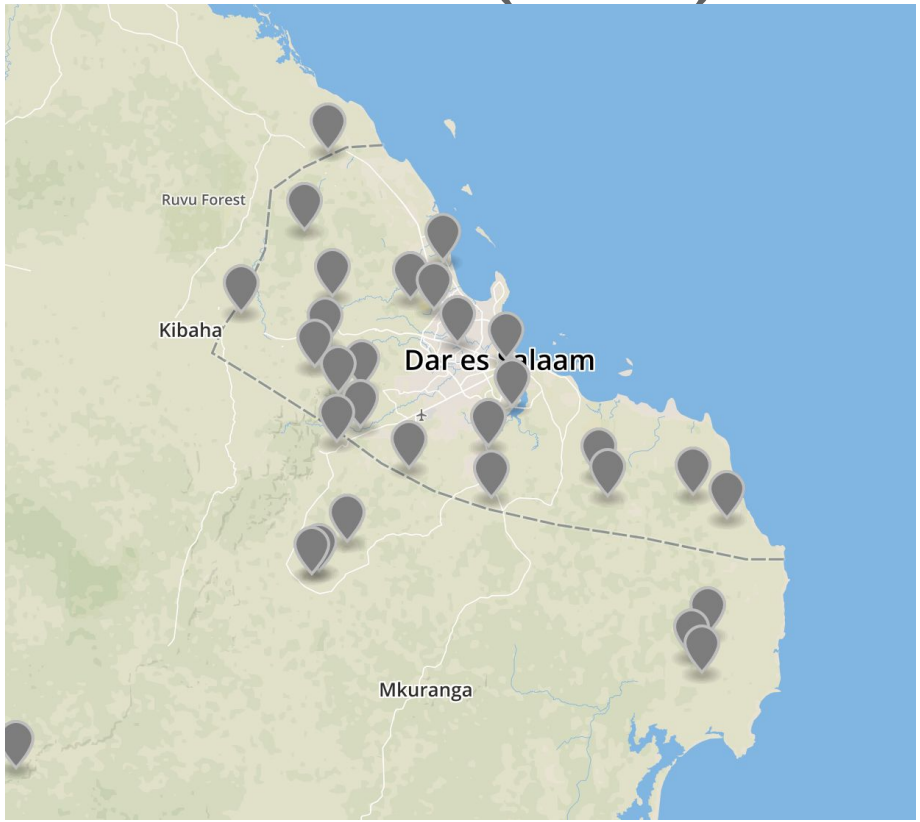
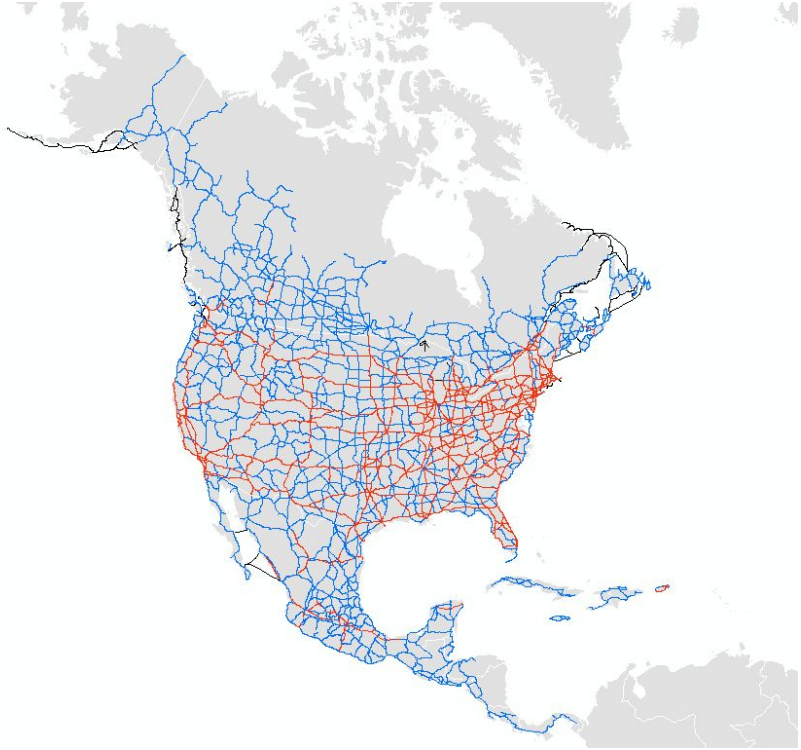
JTS is EVERYWHERE

Net Topology Suite

Vector Data (Points)



Vector Data (Lines)



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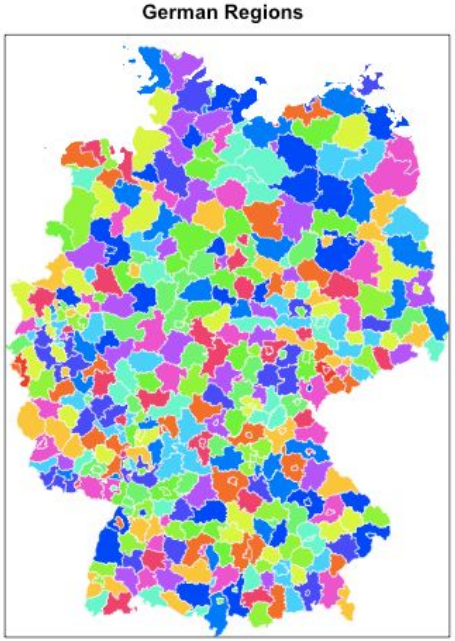
Vector Data (Polygons)

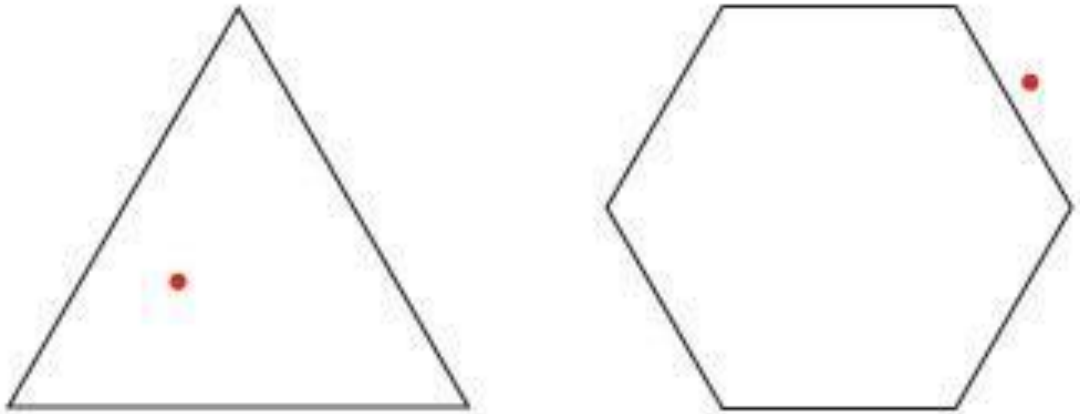


Source: https://ryouready.wordpress.com/2009/11/16/infomaps-using-r-visualizing-german-unemployment-rates-by-color-on-a-map/

Vector Data


Edit feature
Public Building
All fields
Name
Julius Nyerere International Convention Centre
Multilingual name
abbreviation
JNICC
Address
123
Shaaban Robert Street
Dar es Salaam
Postcode
Levels
1
Height (Meters)
Unknown
Point
Line
Area
Save
Embassy of Denmark
Clearing Office
Hazina Building

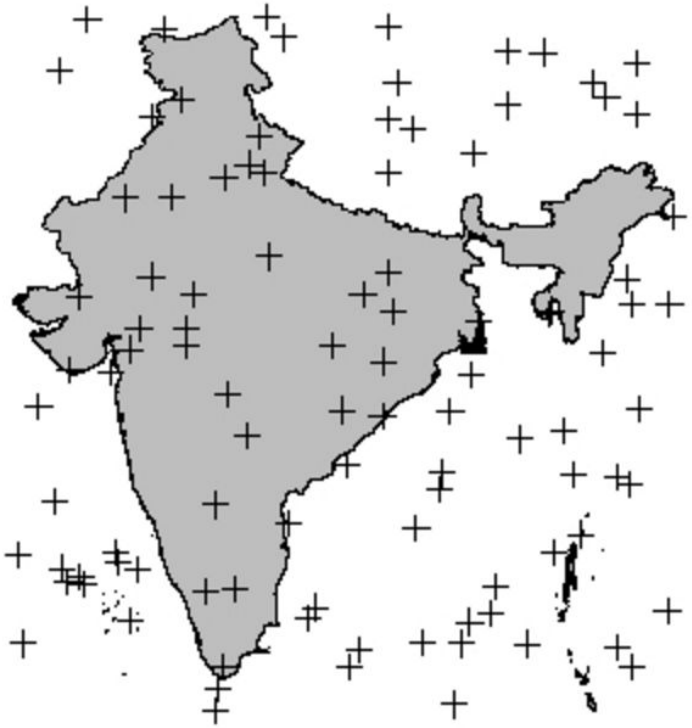
Contains



True

False

Contains

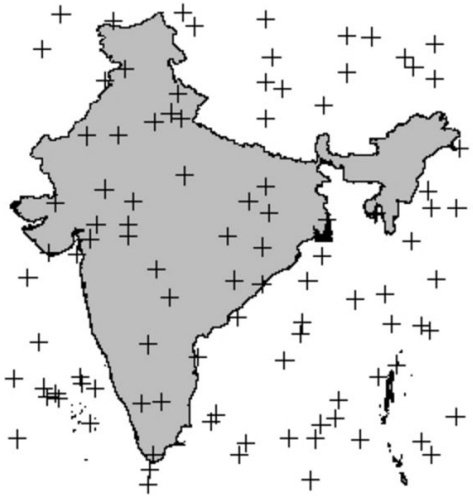


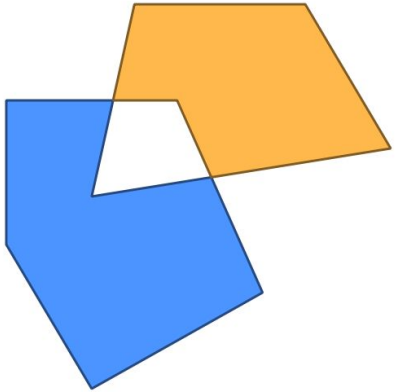
JTS Topology Suite

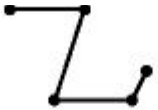
Representations:

OGC Simple Features

- Point
- LineString
- LinearRing
- Polygon
- MultiPoint
- MultiLineString
- MultiPolygon
- GeometryCollection







OGC®
Making location count.

JTS Topology Suite

Predicates (DE-9IM)

- Equals
- Disjoin
- Intersects
- Touches
- Crosses
- Within
- Contains
- Overlaps
- Covers
- CoveredBy

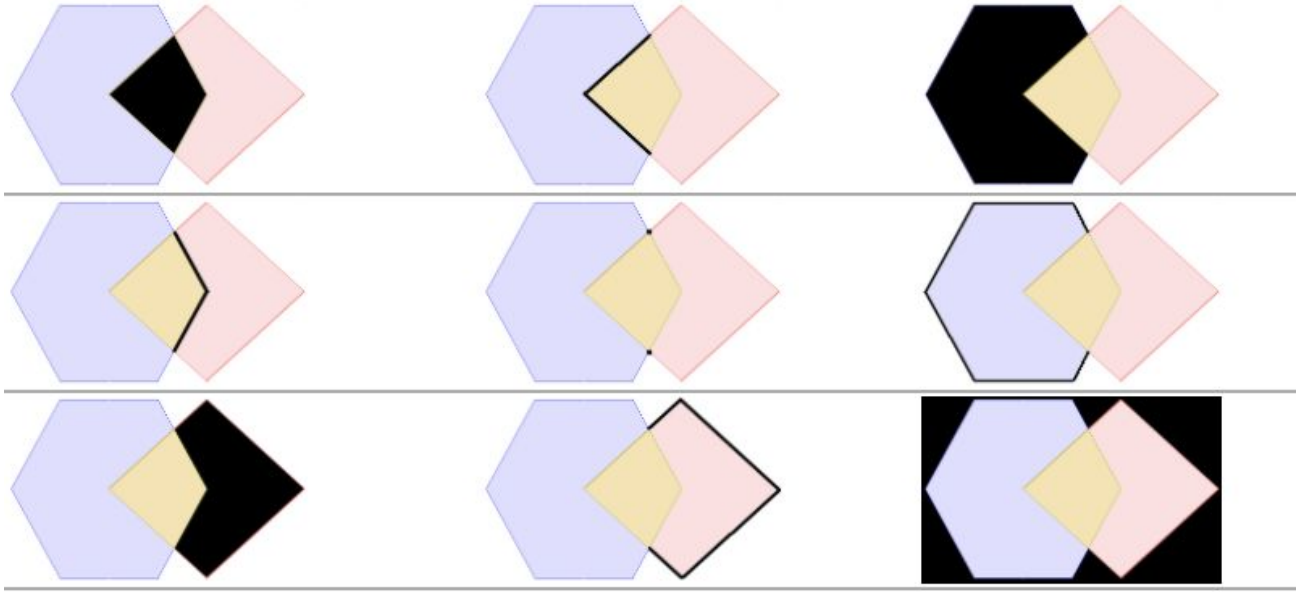
	Interior	Boundary	Exterior
Interior	 $\dim[I(a) \cap I(b)] = 2$	 $\dim[I(a) \cap B(b)] = 1$	 $\dim[I(a) \cap E(b)] = 2$
Boundary	 $\dim[B(a) \cap I(b)] = 1$	 $\dim[B(a) \cap B(b)] = 0$	 $\dim[B(a) \cap E(b)] = 1$
Exterior	 $\dim[E(a) \cap I(b)] = 2$	 $\dim[E(a) \cap B(b)] = 1$	 $\dim[E(a) \cap E(b)] = 2$

LocationTech

JTS Topology Suite

Overlays

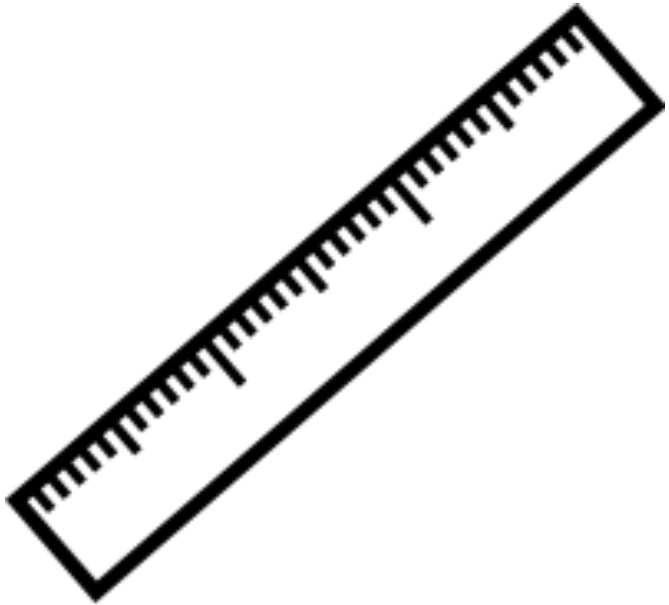
- Intersection
- Union
- Difference
- SymDifference



JTS Topology Suite

Measurements

- Length
- Area
- Distance



JTS Topology Suite

IO:

- WKT
- WKB
- GeoJSON
- KML
- GML2

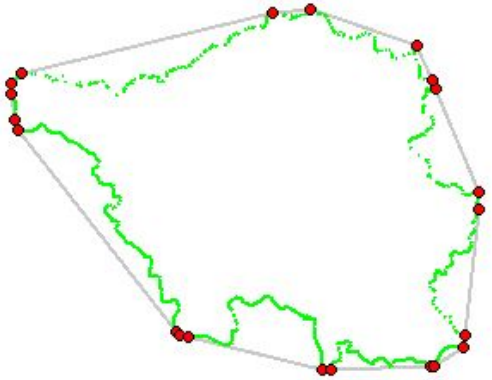
```
wkt_geom
Polygon ((-105.03792611059080286
39.780147822254917 86, -105.048184000999626 16
39.758562655978487 04, -105.022844385567410 09
39.754187208738507 31, -105.012312878647549 04
39.767899828516576 12, -105.013647221999889 33
39.783891712884617 68, -105.037926110590802 86
39.780147822254917 86))
```

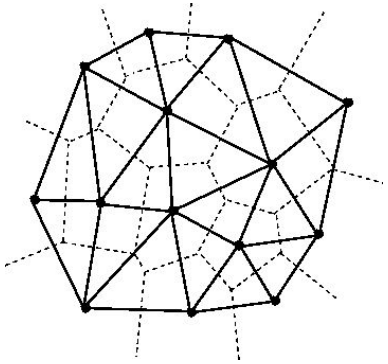
```
{
  "type": "Feature",
  "geometry": {
    "type": "Point",
    "coordinates": [
      -122.65335738658904,
      45.512083676585156
    ]
  },
  "properties": {
    "name": "Hungry Heart Cupcakes",
    "address": "1212 SE Hawthorne Boulevard",
    "website": "http://www.hungryheartcupcakes.com",
    "gluten free": "no"
  }
}
```

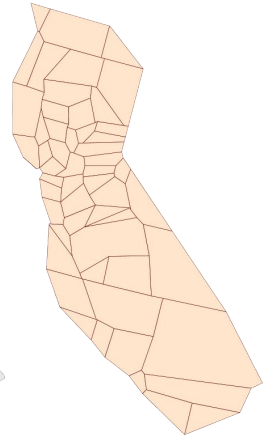
JTS Topology Suite

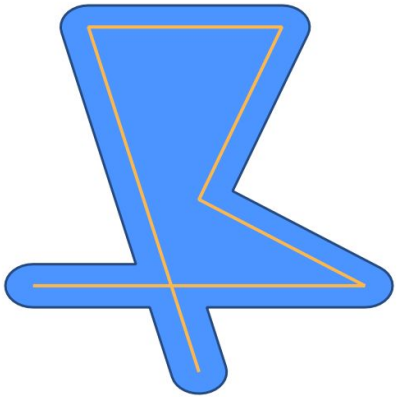
Algorithms

- Convex Hull
- Buffer
- Validation
- Dissolve
- Polygonization
- Simplification
- Triangulation
- Voronoi
- Linear Referencing
- and more...





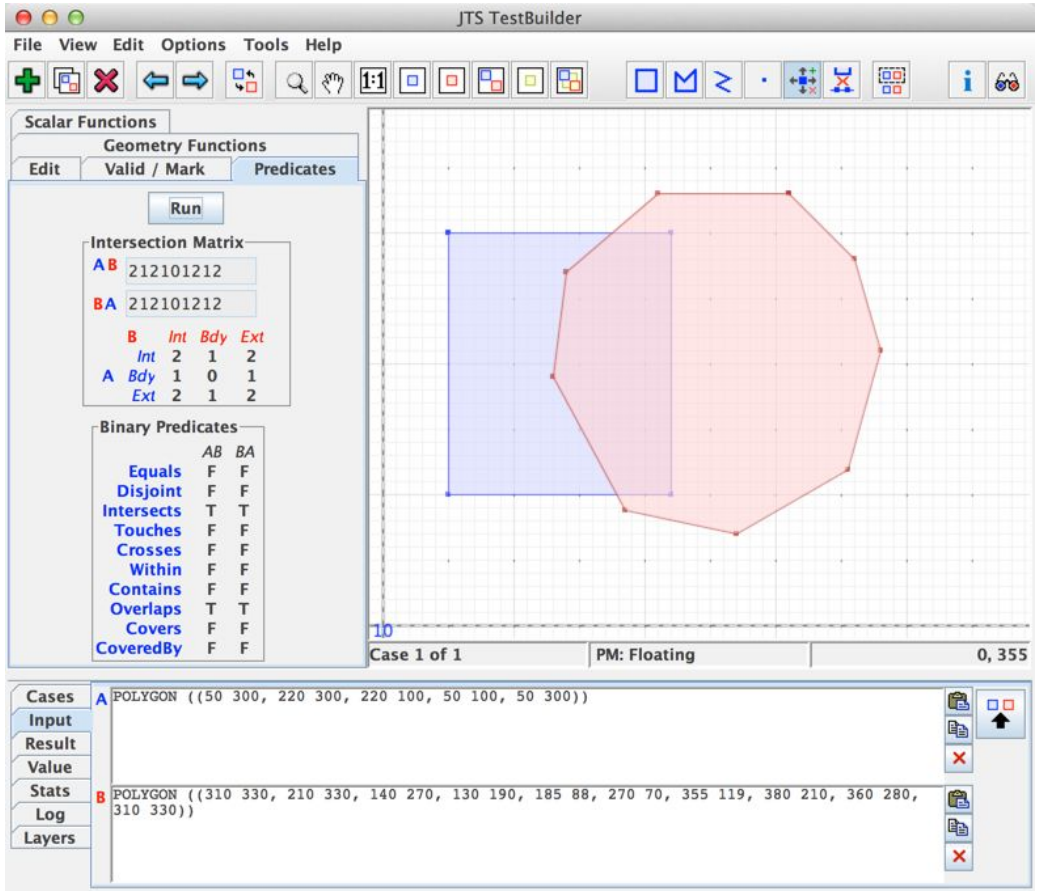




JTS Topology Suite

Applications

- TestBuilder
- TestRunner

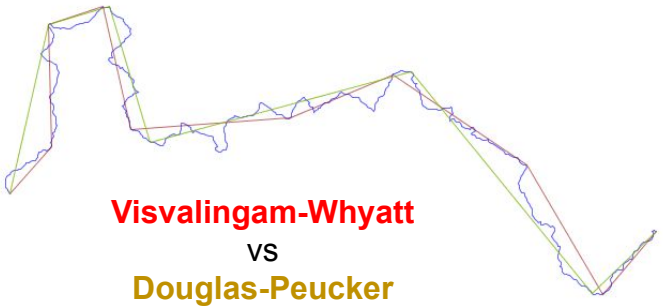


JTS 1.14

JTS 1.14 Release

January 2016

- LineDissolver
- edgegraph package
- Visvalingam-Whyatt simplification



Visvalingam-Whyatt
vs
Douglas-Peucker

Improvements:

- Improved thread-safety
- Fixed Java 7 compatibility
- Added Spatialite WKB
- CoordinateSequence
- many bug fixes and performance improvements

JTS I/O

- KML Writer
- GeoJsonReader/Writer
- Oracle SDO Performance

JTS 1.14 with Maven

JTS 1.14

```
<dependency>
    <groupId>com.vividsolutions</groupId>
    <artifactId>jts-core</artifactId>
    <version>1.14.0</version>
</dependency>
```

Published

Official release on SF

- Install into local repo

On Maven Central

- We do not know who did this!

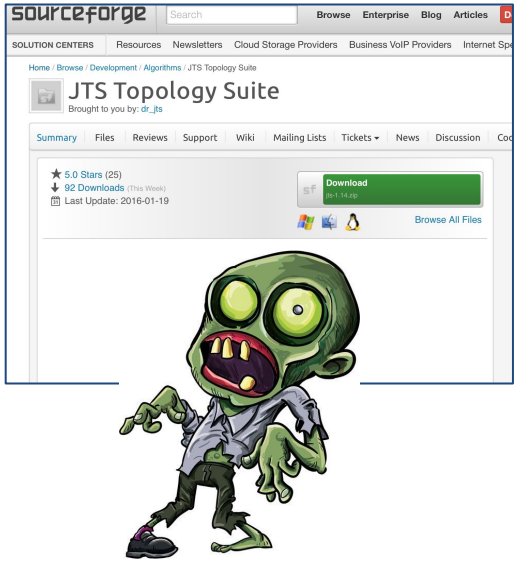
JTS 1.15

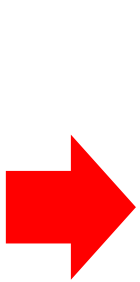
JTS 1.15 Release

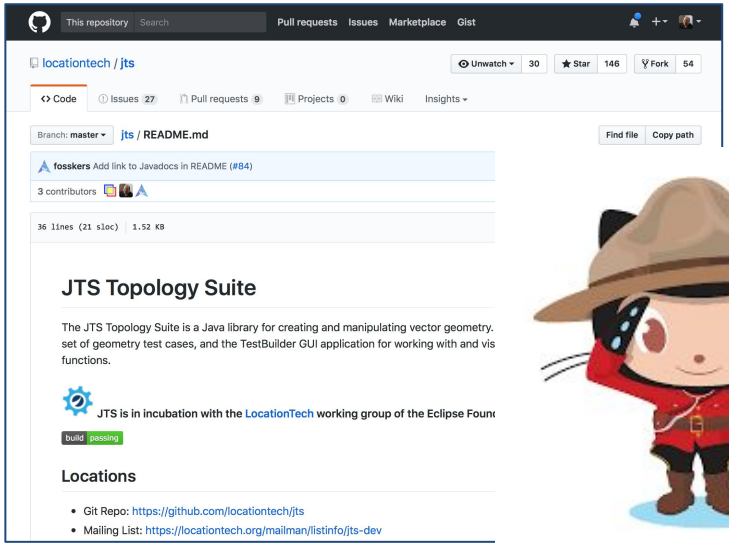
- Focus on codebase
  - organization and packaging
- Some functionality improvements
  - K Nearest Neighbor search for STR-Tree
  - Improve handling of Quadtree queries with null Envelope
  - Intersects now supports GeometryCollection
  - JTSTestRunnerCmd command-line app

Sourceforge → GitHub

- Moving from SVN to GIT
- https://github.com/locationtech/jts





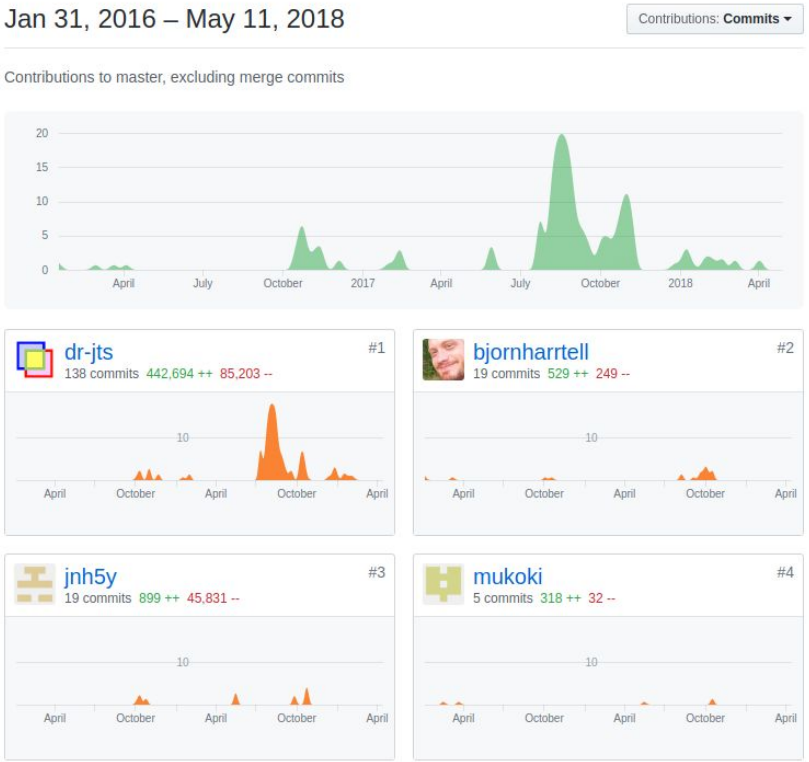


Why choose GitHub?

- High Visibility
- Great tools
  - Git tools
  - Issue tracking
  - Pull Requests
  - Continuous Integration
  - Website
- Easier for contributions
- Where the action is!

GitHub: JTS Project Activity

- Pull Requests
  - 76 accepted, 15 open
- Issues
  - 39 closed, 49 open



Mavenization

- Build chain now uses Maven instead of Ant
  - Easier to build and use
  - Easy Eclipse IDE configuration
- Unit tests run by Maven build
  - including XML tests
- Better release story
  - Code artifacts will be hosted on Maven Central
  - Apps built as fat-jars (TestBuilder, TestRunner)
- To Do
  - Work on packaging a distro with source, scripts, etc...

Modular Codebase

- Codebase organized into modules
  - **jts-core** - geometry implementation for use
  - **jts-tests** - extensive testing for correctness and stability
  - **jts-io** - read and write geometry
  - **jts-example** - examples of using the jts api
  - **jts-lab** - experimental playground use at your own risk
  - **jts-app** - test builder application for defining tests
- better clarity of internal dependencies

JTS Joins LocationTech

- LocationTech offers
  - project infrastructure
  - project visibility
  - stability, governance
- Immediate benefits
  - More team members
  - Synergy with other LocationTech projects
  - In-depth legal review for IP (Intellectual Property) cleanliness
- Initial Work
  - Project Application
  - License Change
  - LocationTech Incubation
  - Build Infrastructure
  - Official Maven Deployment
- Long term hopes
  - Additional Contributors
  - Funding for JTS 2.0

LocationTech Incubation

A new License

- Eclipse Public License
- Eclipse Distribution License (BSD-3 Clause License)

Challenges:

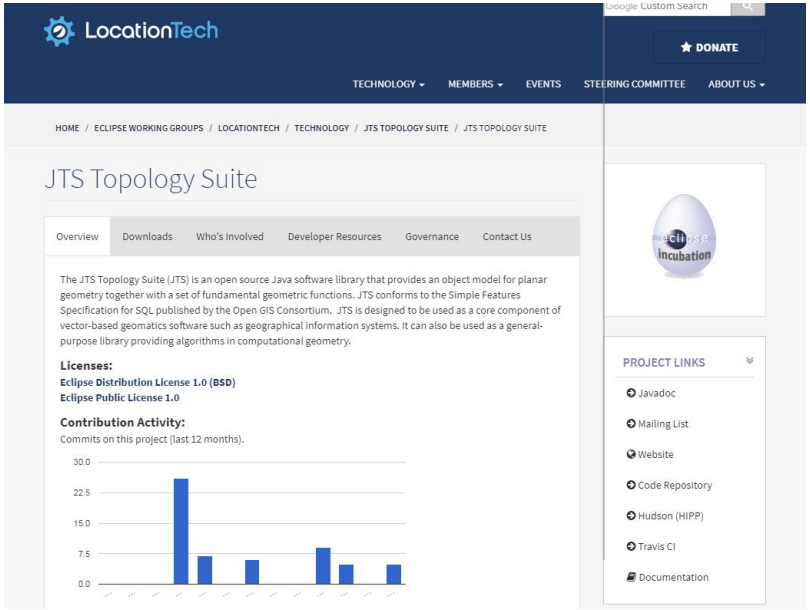
- Contact assorted contributors (because we did not have a CLA)
- changing package names
- Opportunity to work together
- Maintaining codebase history

A new home:

- Project Website
- Mailing List
- Build Server
- GitHub repo

LocationTech Project Site

- **`www.locationtech.org/projects/technology.jts`**



JTS 1.15

- Packaging
  - `org.locationtech.jts`
- GitHub repo
  - https://github.com/locationtech/jts
- Releases available on Maven Central (and LT Nexus)
- Snapshots Available via LT Nexus
  - https://repo.locationtech.org/

Using JTS 1.15 with Maven

JTS 1.14

```
<dependency>
    <groupId>com.vividsolutions</groupId>
    <artifactId>jts-core</artifactId>
    <version>1.14.0</version>
</dependency>
```

JTS 1.15.1

```
<dependency>
    <groupId>org.locationtech.jts</groupId>
    <artifactId>jts-core</artifactId>
    <version>1.15.1</version>
</dependency>
```

Using JTS 1.15.2-SNAPSHOT

JTS 1.14

```
<dependency>
    <groupId>com.vividsolutions</groupId>
    <artifactId>jts-core</artifactId>
    <version>1.14.0</version>
</dependency>
```

JTS 1.15.2-SNAPSHOT

```
<dependency>
    <groupId>org.locationtech.jts</groupId>
    <artifactId>jts-core</artifactId>
    <version>1.15.2-SNAPSHOT</version>
</dependency>
....
 <repositories>
    <repository>
        <id>locationtech-snapshots</id>
        <url>https://repo.locationtech.org/content/groups/snapshots</url>
        <snapshots>
            <enabled>true</enabled>
        </snapshots>
    </repository>
 </repositories>
```

Migration to JTS 1.15

- New module structure
  - `jts-core`
  - `jts-io-common` - GeoJSON
  - `jts-io-ora` - Oracle support
  - `jts-io-sde` - SDE support
  - `jts-tests` - XML Tests & TestRunner
- Change package names
  - `org.locationtech.jts.*`
- Change Maven reference
  - GroupId change: `com.vividsolutions` to `org.locationtech.jts`

JTS 1.15.1

- Support projects migrating
- Java Roadmap Compatibility
  - module names for “jigsaw” packaging
- Fixes
  - Geometry.clone() → Geometry.copy()

Coming Soon!

JTS Roadmap

JTS 1.16 Coming Soon!

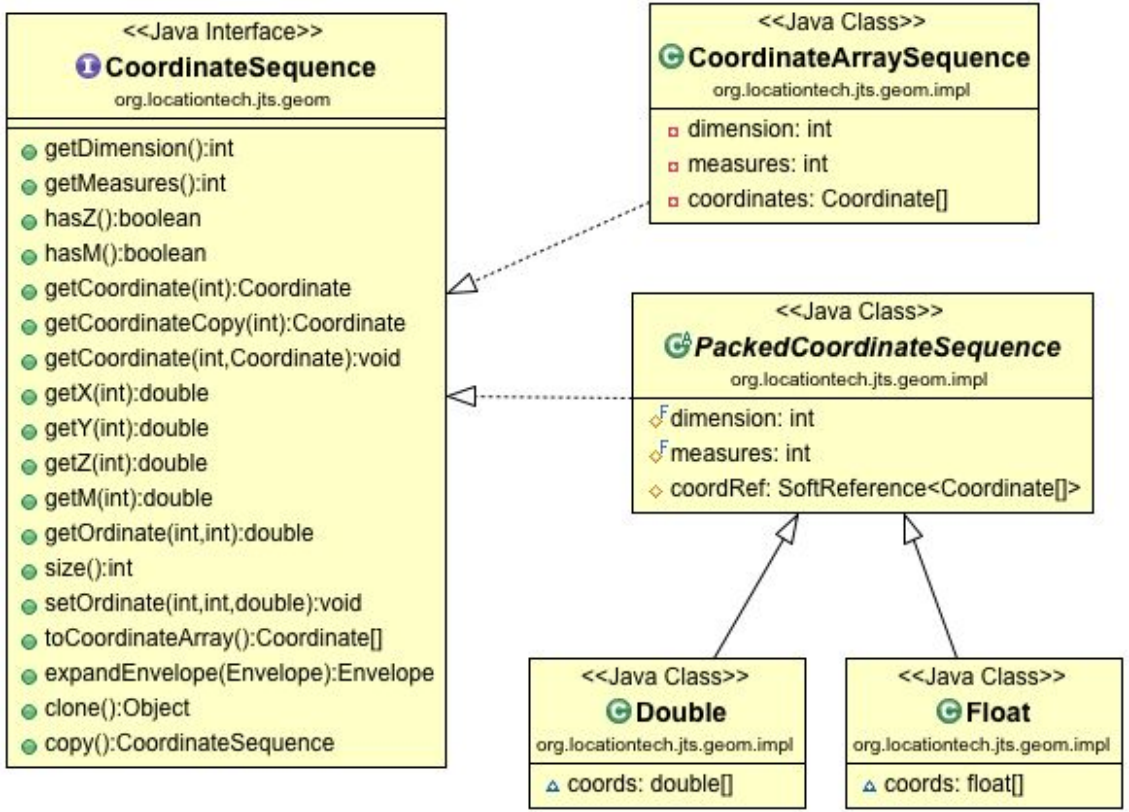
- How soon?
  - Release Candidate 1.16.0-RC1 is already available
  - Scheduled 1.16.0 for September 5th Eclipse release review
    - Final IP issues being resolved
      (checking in new icons for the test builder application)
    - Two week release review

CoordinateSequence XYZM

Dimension: *number of ordinates in each coordinate, this total includes any measures.*

Measure: number of measures included in dimension for each coordinate

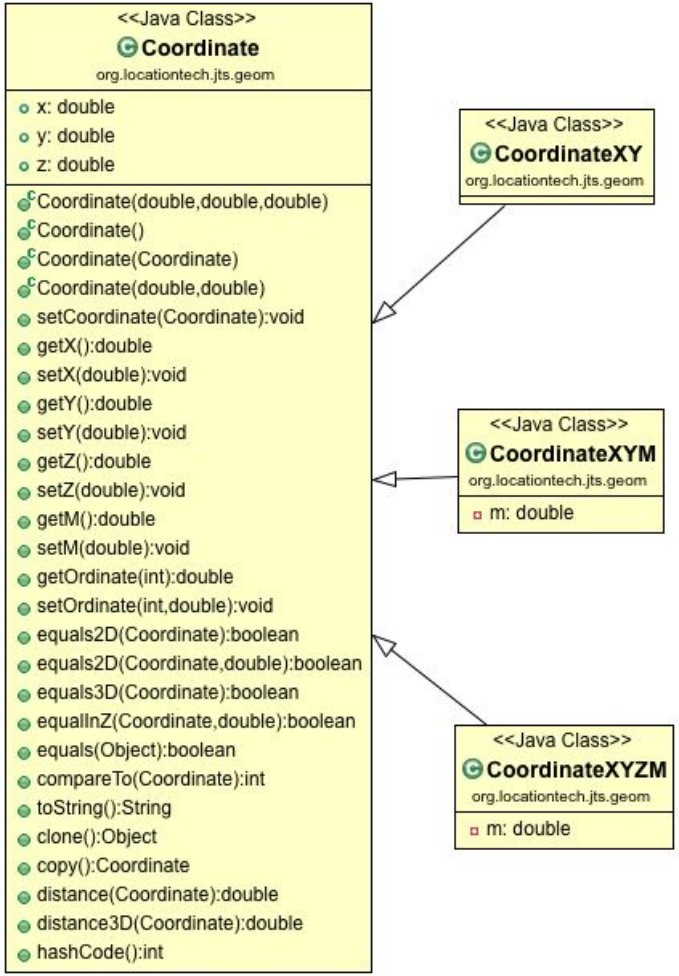
Coordinate	Dimension	Measures
XY	2	0
XYM	3	1
XYZ	3	0
XYZM	4	1



Coordinate XYZM

Subclasses for XY, XYM, XYZM representations.

The field “z” is deprecated! Please use accessors to access fields.



WKT XYZM Support

Felix has extended WKT reader/writer support to support XYZM.

The reader has a flag to support “legacy” JTS representation.

Supports Well-Known Text representations for Z, M, ZM forms:

```
LINESTRING (10 10, 20 20, 30 40)
LINESTRING Z(10 10 10, 20 20 10, 30 40 10)
LINESTRING M(10 10 11, 20 20 11, 30 40 11)
LINESTRING ZM(10 10 10 11, 20 20 10 11, 30 40 10 11)
```

JTS Topology Suite

IO:

- WKT
- WKB
- GeoJSON
- KML
- GML2
- TWKB (In progress!)

"Tiny Well-known Binary" or "TWKB"

Version	Release
0.23	May 1, 2015

Abstract

TWKB is a multi-purpose format for serializing vector geometry data into a byte buffer, with an emphasis on minimizing size of the buffer.

Why not WKB?

The original OGC "well-known binary" format is a simple format, and is capable of easily representing complex OGC geometries like nested collections, but it has two important drawbacks for use as a production serialization:

- it is not aligned, so it doesn't support efficient direct memory access; and,
- it uses IEEE doubles as the coordinate storage format, so for data with lots of spatially adjacent coordinates (basically, all GIS data) it wastes a lot of space on redundant specification of coordinate information.

A new serialization format can address the problem of alignment, or the problem of size, but not both. Given that most current client/server perfomance issues are bottlenecked on network transport times, TWKB concentrates on solving the problem of serialization size.

Basic Principles

TWKB applies the following principles:

- Only store the absolute position once, and store all other positions as delta values relative to the preceding position.
- Only use as much address space as is necessary for any given value. Practically this means that "variable length integers" or "varints" are used throughout the specification for storing values in any situation where numbers greater than 128 might be encountered.

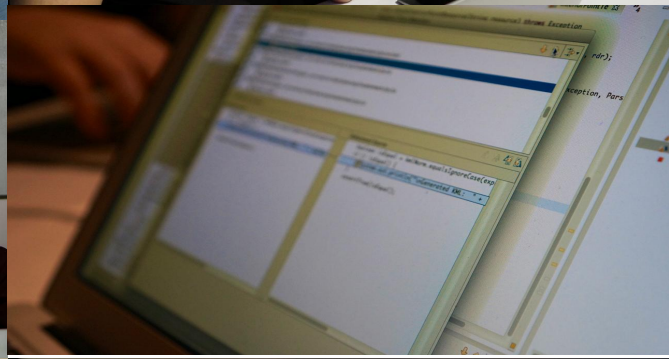
JTS Community Building

JTS Team Code Sprints

- 2016 January and November
  - Sourceforge → GitHub
  - Build change to maven
  - Addressed “Intellectual Property” review questions

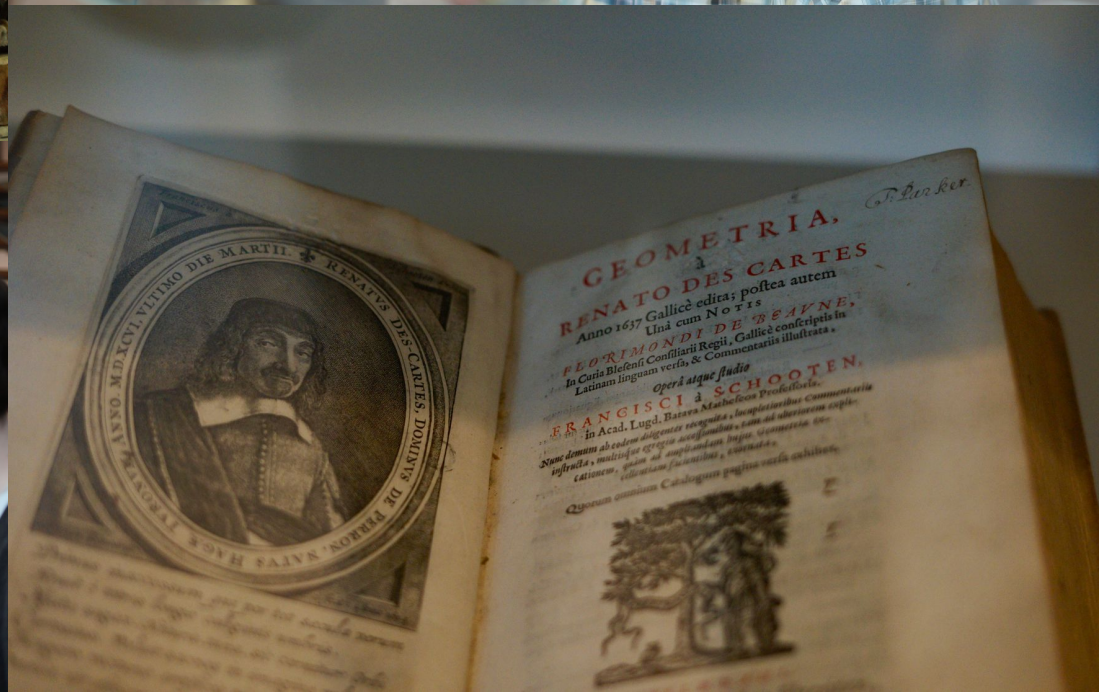





JTS Team Code Sprints

- 2018 Bon Code Sprint
  - Java 10 compatibility with “jigsaw” module names
- 2017 FOSS4GNA Code Sprint
  - Helping projects upgrade
  - GeoTools PostGIS DataStore TWKB
  - Join us Thursday for Community and workshop day!


GEOMETRIA,
RENATO DES CARTES
Anno 1637 Gallicè edita; postea autem
Una cum NOTIS
FRANCISCI à SCHOOTEN,
in Acad. Lugd. Batava Mathescos Professoris.

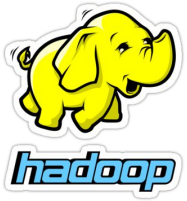
JTS in the ‘Cloud’

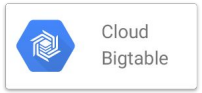
JTS is EVERYWHERE

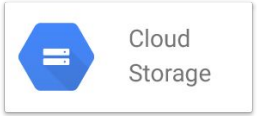
Net Topology Suite

Cloud Projects using JTS

Big Data Ecosystem







Distributed Spatial Goals

- Distribute the **storage** of vector and raster data
  - Database integration (HBase, Accumulo, C*)
  - File format integration (Arrow, Avro, Parquet)

- Distribute the **processing** of geospatial data
  - MapReduce integration
  - Spark integration
  - **SparkSQL**

JTS + Spark

- In 2015-2016
  - GeoMesa had RDD level support for JTS Geometry types (as well as GeoTools SimpleFeatures)
- In 2017
  - GeoMesa integrated with Spark's SQL query planner
    - Added Spatial UDTs
    - Added Spatial UDFs
    - Adds PostGIS syntax to Spark
    - (Limitation) Tied to GeoMesa
- In 2018
  - GeoMesa project refactored JTS+Spark module
    - Being used by the RasterFrames project

JTS + Spark going forward

- The JTS + Spark integration is pretty straightforward; the goal is to have more projects integrate with it.
  - Performance enhancements can shared by all the projects

- Currently, each Spark release introduces changes to the UDT/UDF protected interfaces.
  - This risk is best shared by a community (rather than having each project reimplement and update their individual projects)

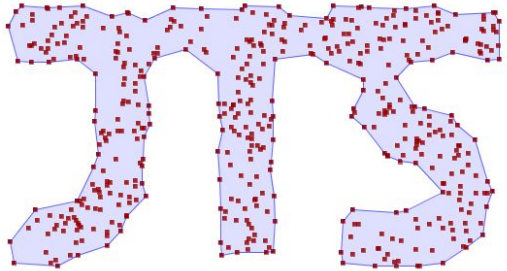
JTS 2.0 Roadmap / Wishlist

Algorithm Improvements

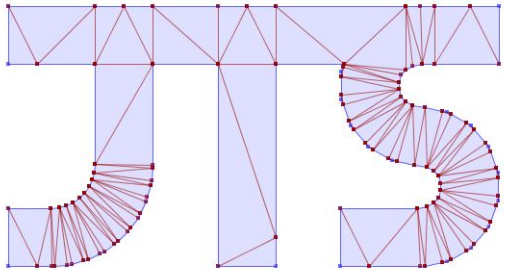
- Goal: improve some key JTS algorithms
  - Overlay
    - Snap-rounding (no more TopologyExceptions!)
    - Support PreparedGeometry for caching
    - Fast & robust Clip to Rectangle
  - Spatial Predicate improvements
    - Streaming / Lazy evaluation with short-circuiting
    - User-defined precision model
    - Less sensitive to valid geometry (e.g. Intersects)
  - Distance
    - Support cached PreparedGeometry

New Algorithms

- Concave Hull
- Polygon Triangulation
- Polygon Cleaning (“MakeValid”)
- Split Geometry by Line
- Polygon Coverage Simplification



Concave Hull



Polygon Triangulation

New API - JTS 2.0

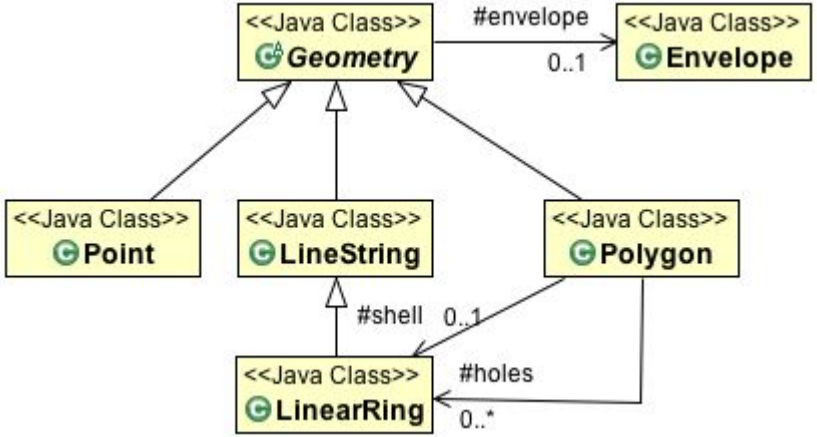
- Concept for a redesign of JTS
- Key Goals
  - Interface-based Geometry access
  - Immutable Geometry objects
  - Geodetic (WGS84) support, with some basic algorithms
  - Pluggable/discoverable Geometry operation framework
  - Coordinate extensions (XY, XY+M)
- Non-goals
  - Backwards compatibility
  - Improving geometry algorithms

JTS 1.0 Baseline

SFQL, GML2

Primitives:

- Geometry
- Point
- LineString
- Polygon

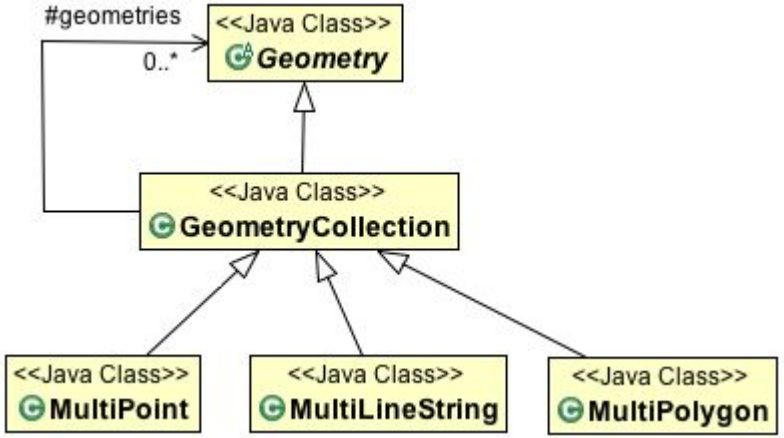


JTS 1.0 Baseline

SFQL, GML2

Collections

- GeometryCollection
- MultiPoint
- MultiLineString
- MultiPolygon

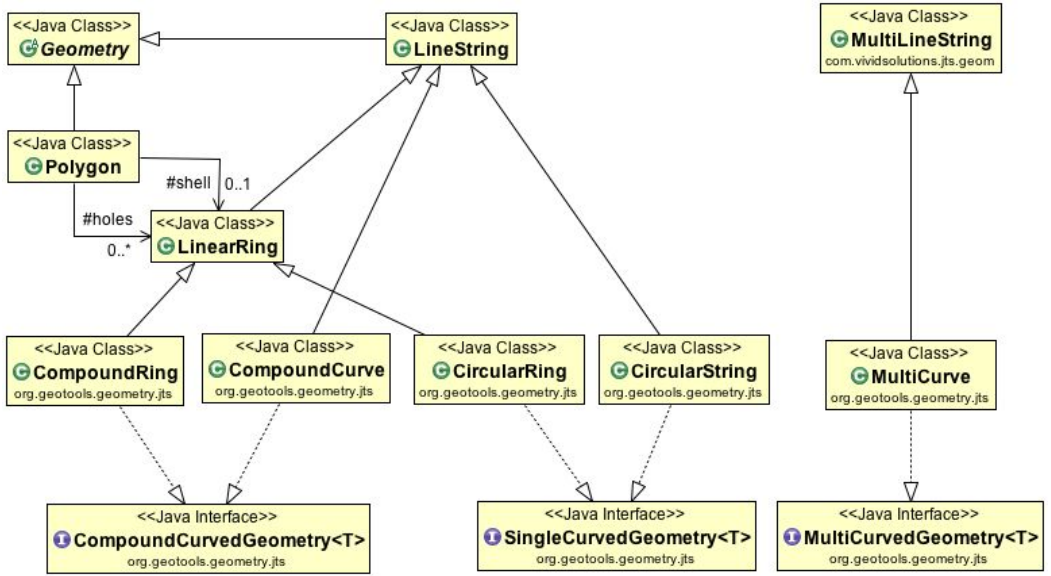


JTS 2.0 Challenge

SQL/MM, GML3, ISO19107

Primitives:

- Point
- Curve
- Surface

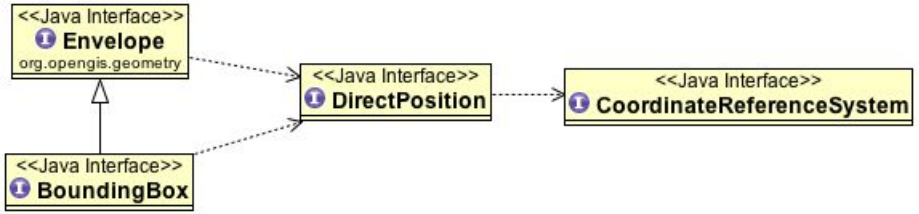


JTS 2.0 Challenge

SQL/MM, GML3, ISO19107

Geometry defined using:

- Positions
- Reference System



JTS 2.0 Challenge

JTS Topology Suite

Linear Geometry

Euclidean operations

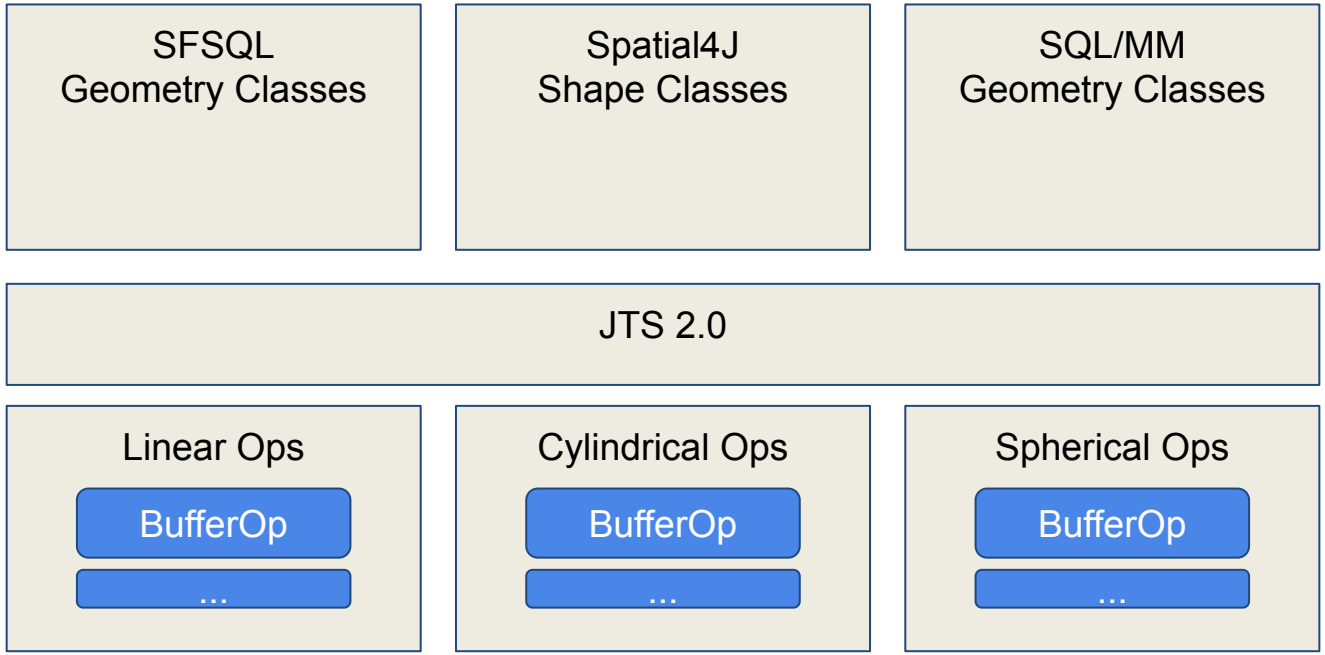
Spatial4J

Curved Geometry

Cylindrical operations

Spherical operations

JTS 2.0 Approach



Join JTS Topology Suite

Shape the Future

Contributing to JTS

- Register as a Contributor
  - Sign the Eclipse Contributor Agreement
  - https://www.eclipse.org/legal/ECA.php
- Develop a patch, making sure to include
  - Javadoc
  - Unit Tests - JUnit and/or JTS XML tests
- Make a Pull Request on GitHub
  - Acknowledge code is IP clean by signing-off each Git commit
  - Make sure the Travis CI validation tests pass

See also https://github.com/locationtech/jts/blob/master/CONTRIBUTING.md

Join Us at the Code Sprint!

Thursday, at the code sprint, we will work on two projects

1. Polishing a new TWKB Reader/Writer
2. Upgrading the GeoServer ecosystem to LocationTech JTS

Questions?

Project Resources

- Source Code repo
  - https://github.com/locationtech/jts
- Issue Tracker
  - https://github.com/locationtech/jts/issues
- Mailing List
  - https://dev.locationtech.org/mailman/listinfo/jts-dev
- Project website
  - https://locationtech.github.io/jts
- Javadoc
  - https://locationtech.github.io/jts/javadoc

Thank you from the JTS Team