JTS
Topology Suite

An API for Processing Linear Geometry

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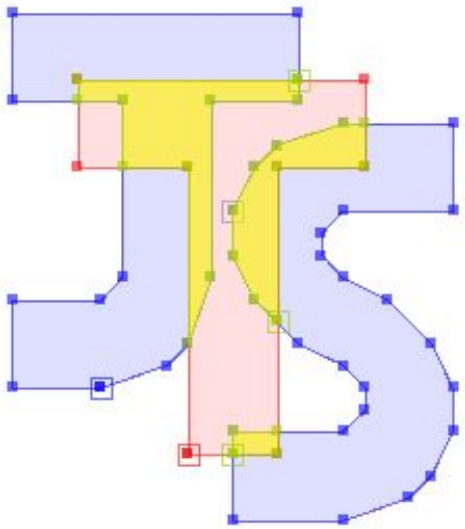
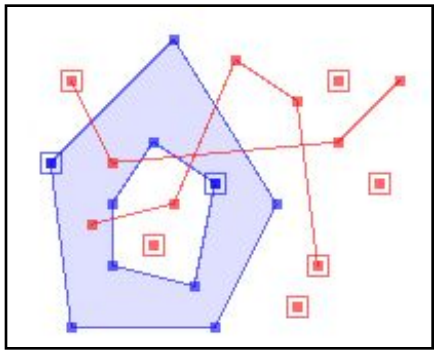
JTS Topology Suite

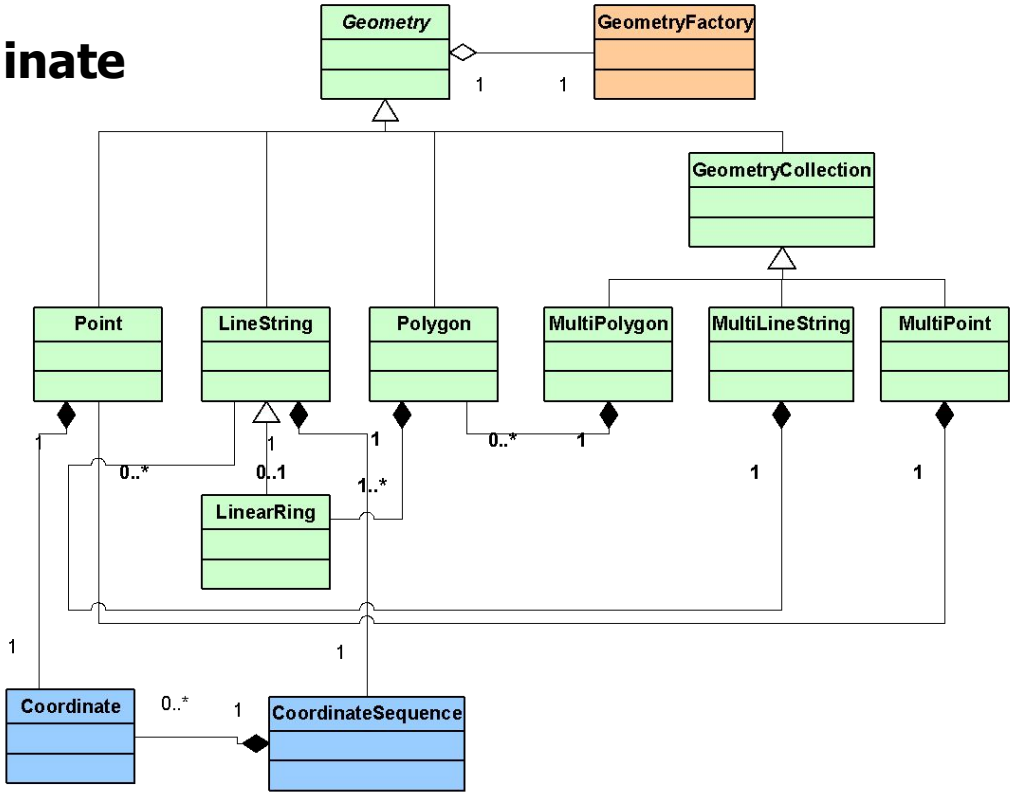
- **Core API for processing Geometry**
- **Full implementation of *OpenGIS Consortium Simple Features for SQL* specification**
- **Open Source, 100% Java**
- **Design Features:**
  - Fast, production quality
  - Robust
  - Explicit precision model
  - All basic geometry operations
- **History**
  - JTS 1.0 released Feb 2002
  - JTS 1.4 released Nov 2003



Geometry Model

- **Complete model for 2-D linear geometry (following OGC SFS model)**
  - **Point**
  - **LineString, LinearRing**
  - **Polygon (with holes)**
  - **MultiPoint, MultiLineString, MultiPolygon**
  - **GeometryCollection**
- **Supports user-defined coordinate representation**

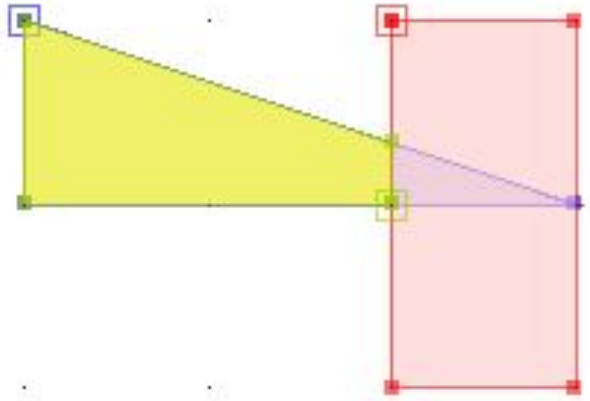




Explicit Precision Model

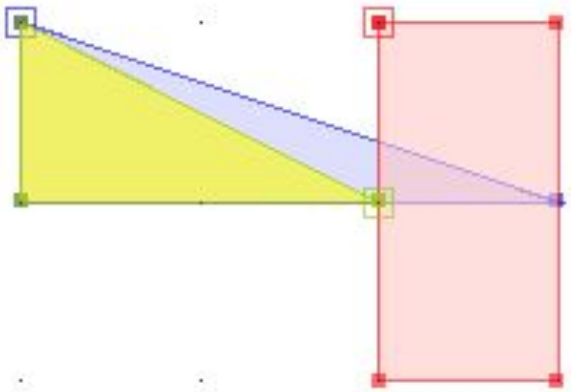
- **JTS provides ability to specify Precision Model of coordinates**
  - **Floating - Double & Single Precision (IEEE-754)**
  - **Fixed - specified # of decimal places**
- **Ensures constructive geometry operations are closed over the specified coordinate space**

Floating



```
POLYGON ((3 2, 1 2, 1 3, 3
2.333333333333333, 3 2))
```

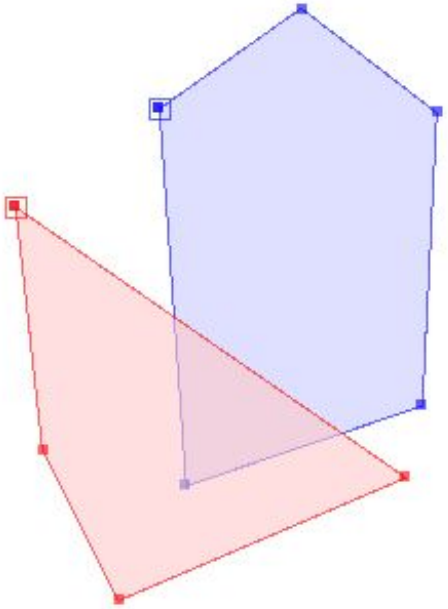
Fixed



```
POLYGON ((3 2, 1 2, 1 3, 3 2))
```

Spatial Predicates

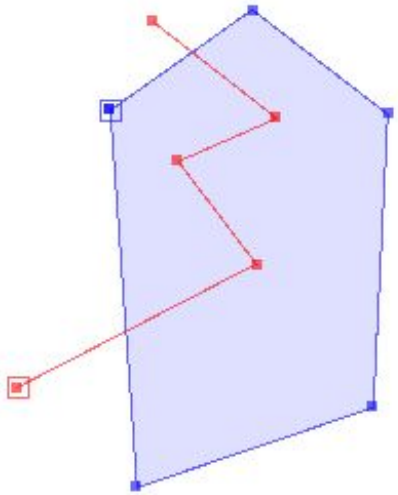
- **Computes the spatial relationship of 2 Geometries**
- **JTS implements the full *Dimensionally Extended 9-Intersection Model (DE-9IM)***
  - Computes dimension of intersection of Interior, Boundary, Exterior
  - General function: **Relate(*pattern*)**
  - Named predicates: **Equals, Disjoint, Intersects, Touches, Crosses, Within, Contains, Overlaps**



		B		
		Int	*Bdy*	*Ext*
A	*Int*	2	1	2
	Bdy	1	0	1
	Ext	2	1	2

Binary Predicates

	AB	*BA*
Equals	F	F
Disjoint	F	F
Intersects	T	T
Touches	F	F
Crosses	F	F
Within	F	F
Contains	F	F
Overlaps	T	T



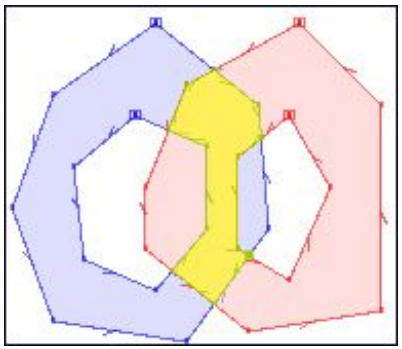
		B		
		Int	*Bdy*	*Ext*
A	*Int*	1	F	2
	Bdy	0	F	1
	Ext	1	0	2

Binary Predicates

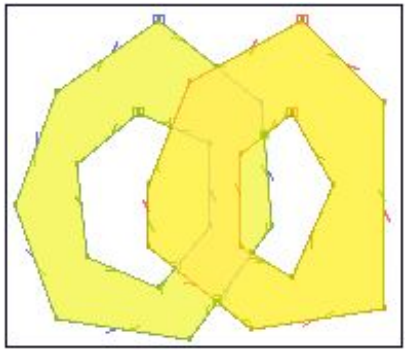
	AB	*BA*
Equals	F	F
Disjoint	F	F
Intersects	T	T
Touches	F	F
Crosses	T	T
Within	F	F
Contains	F	F
Overlaps	F	F

Overlay Methods

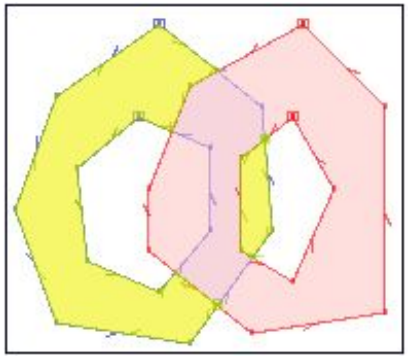
- **Overlay methods = Boolean set-theoretic functions**
  - **Intersection, Union, Difference, Symmetric Difference**



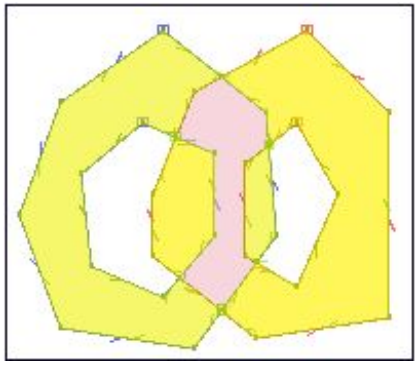
Intersection



Union

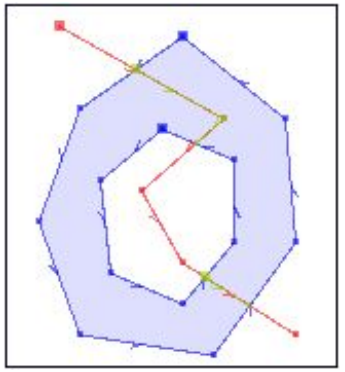


Difference



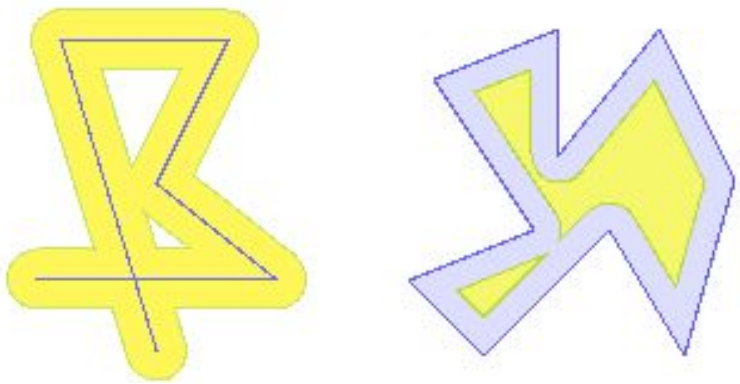
Symmetric Difference

- **Heterogeneous – all geometry types supported**

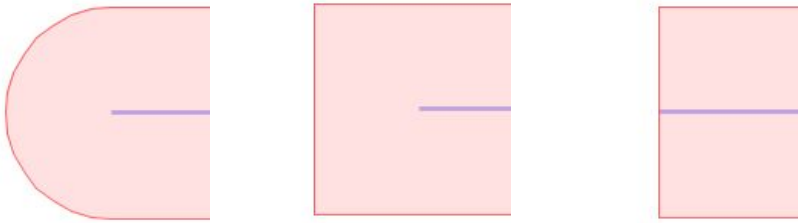


Buffering

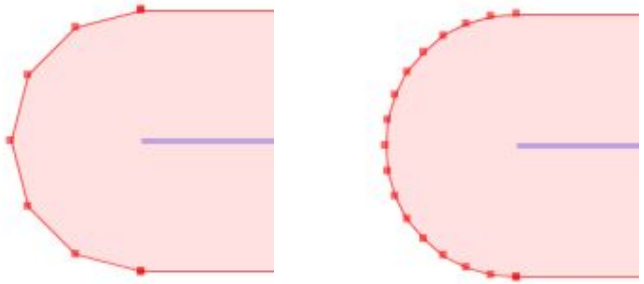
- **Both Positive & Negative buffers**
  - **All Geometry types**
  - **Robust, efficient algorithm**



- **Choice of End Cap Styles**
  - **Round, Square, Butt**

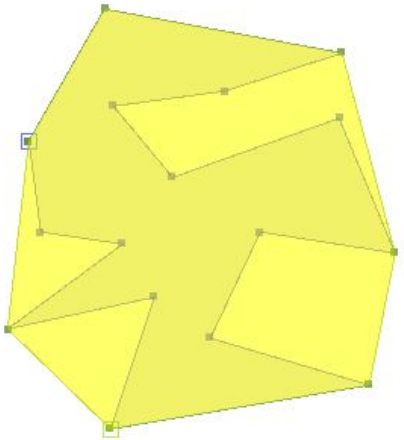


- **Curve Densification is user-controllable**

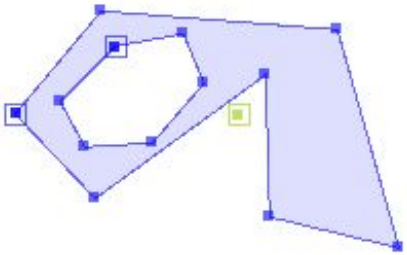


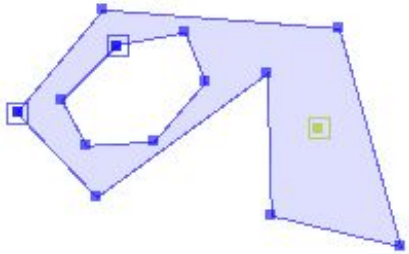
Other Constructive Methods

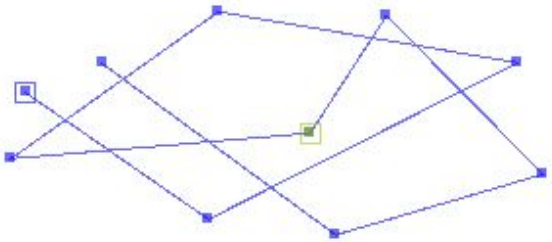
- **Convex Hull**
  - Standard Computational Geometry algorithm



- **Centroid & InteriorPoint**
  - Centroid is center of mass (not necessarily in interior)
  - Interior point *always* in interior, as close to centre as possible
  - all Geometry types supported

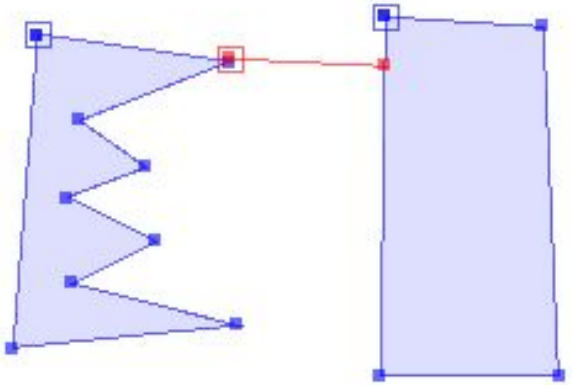






Metric Methods

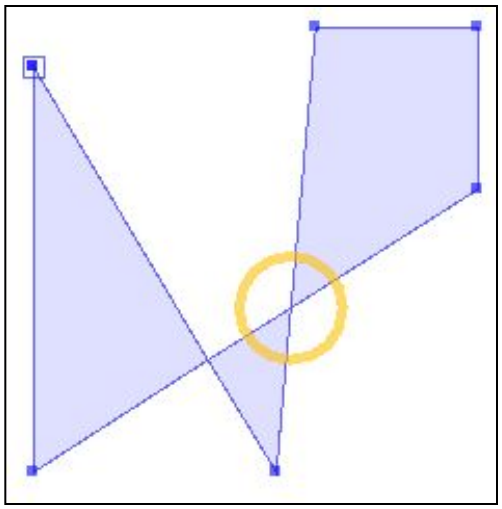
- **Area, Length**
  - Length = Perimeter, for Area geometries
- **Distance**
  - Constructive – computes location of points providing minimum distance



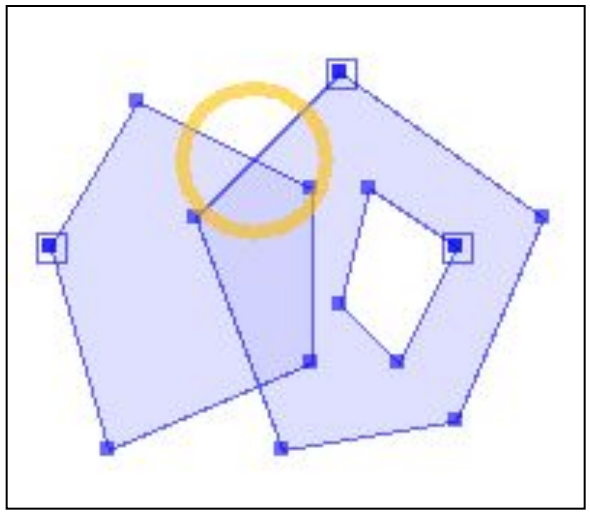
- **WithinDistance**
  - "Limited predicate" allows optimized computation

Geometry Validation

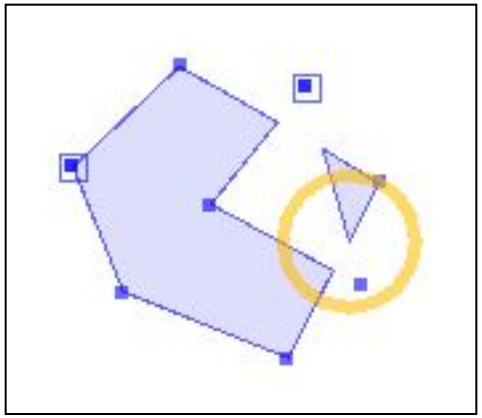
- **Validation of Geometry topology essential to ensure correct spatial processing**
  - Polygons in particular – many possible invalid situations
- **JTS provides full Validation of Topology**
  - **isValid** provides simple good/bad test
  - **ValidOp** class provides detailed error information, including location



Self-intersection



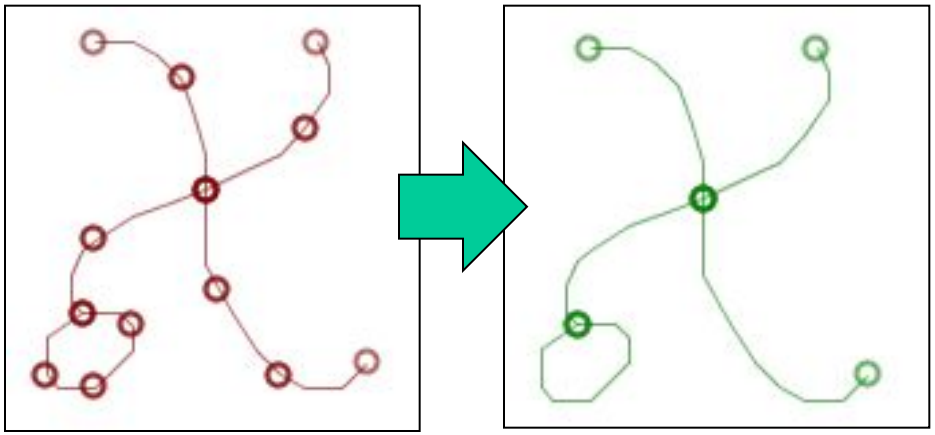
Overlapping Rings



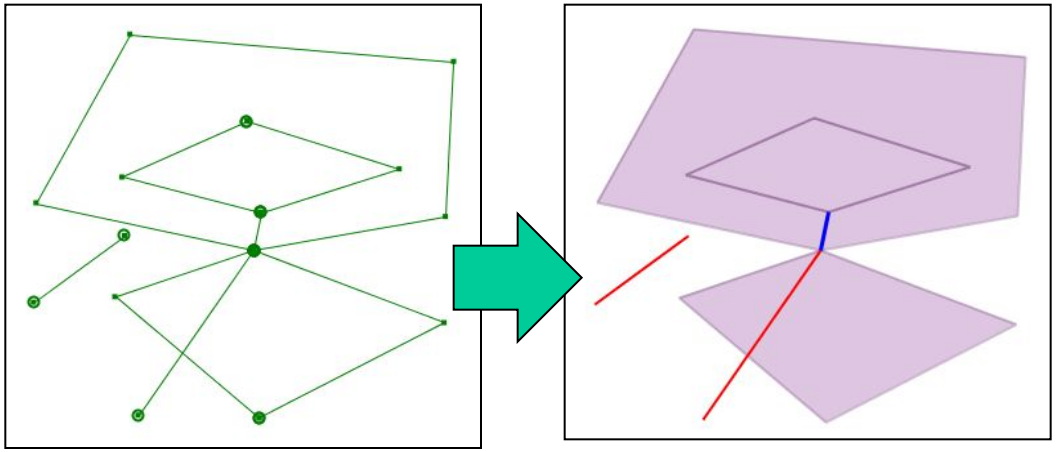
Hole intersects shell

Line Merging & Polygonization

- **Line Merging**
  - Removes 2-nodes from set of LineStrings

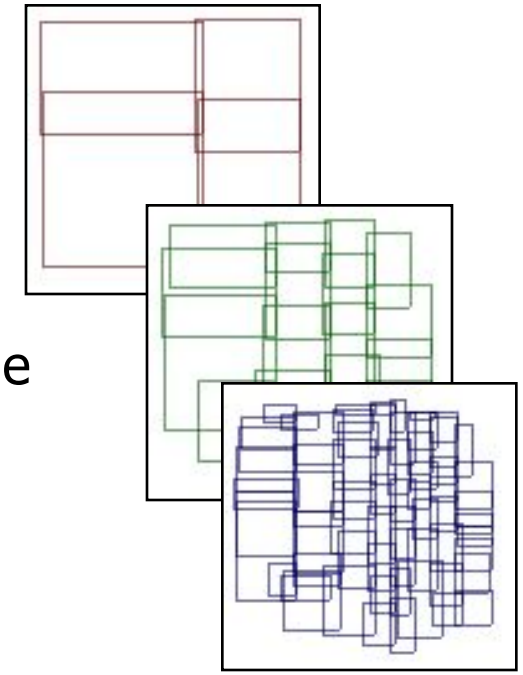


- **Polygonization**
  - Including finding Dangles and Cutlines



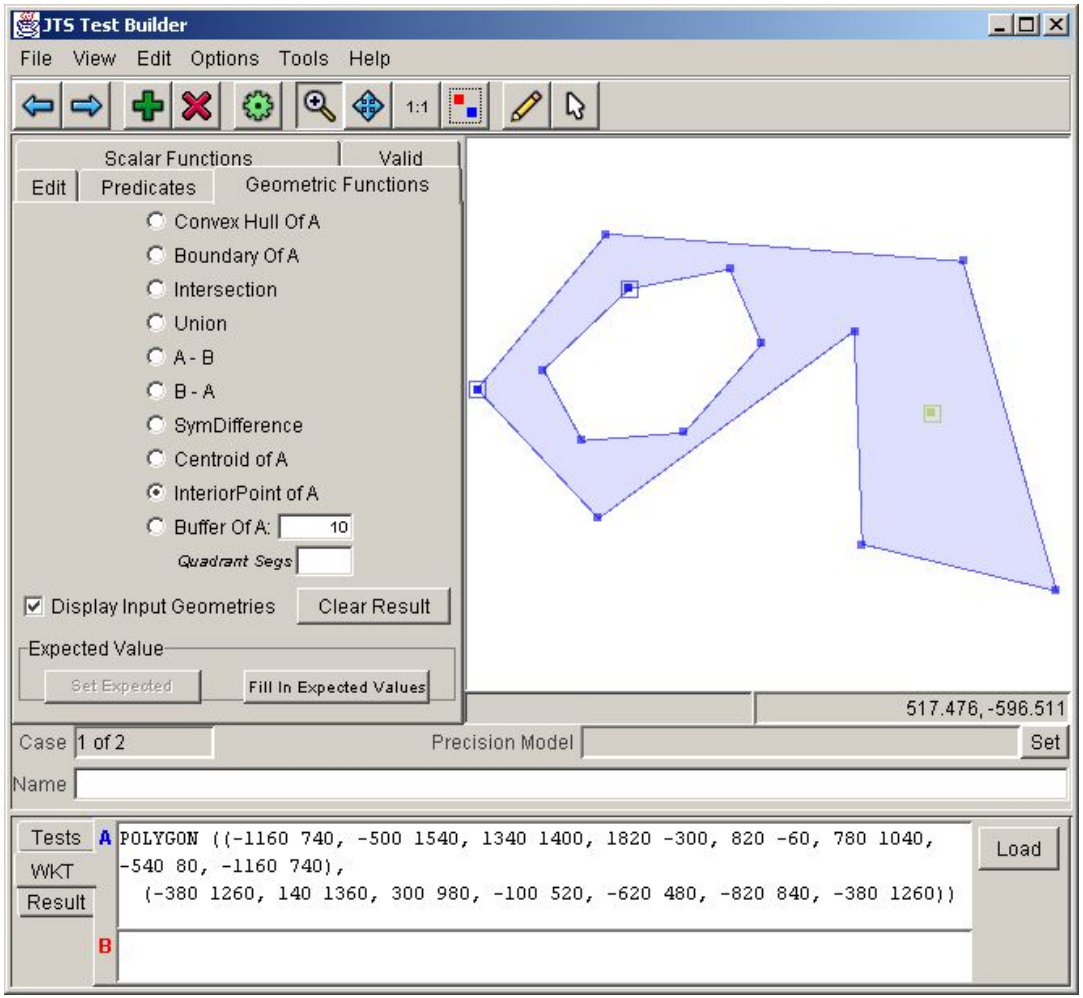
Spatial Algorithms & Structures

- **Numerous basic Computational Geometry algorithms**
  - Line segment intersection, Ring orientation, Point-Line orientation, Point-line distance, etc.
- **Spatial Indexes**
  - Quadtree, STRtree, Bintree, MonotoneChains, SweepLine
- **Line segment Noding**
  - i.e. find and create all intersections in set of Line Segments
- **Planar Graph framework**
- **Precision Reduction**



JTS TestBuilder

- **Create/edit/view geometry**
- **Compute & view results of all JTS methods**



JTS In Use

- **JTS used for core geometry processing in numerous open source and commercial geo-spatial applications**
  - JUMP
  - BC Gov't Electronic Submission Framework
  - Internet Mapping Framework
  - GeoServer / GeoTools
  - Deegree
  - PostGIS (as GEOS)
  - Tlogica (Bulgaria)
- **Other interesting applications**
  - Font Creator (RobMeek.com)

Future Work

- **Fully robust Overlay Operations**
- **Improve performance**
  - e.g. line noding, distance computation
- **Optimize repeated method calls on single Geometry**
  - e.g. "*find all geometries which intersect this geometry*"
- **Improve internal structure**
- **Geometry simplification / generalization methods**
  - Douglas-Peucker line simplification, etc
- **Generalized Distance methods**
  - Hausdorff distance, Frechet distance, etc
- **User-defined Geometry representation**
  - Allows easier adaptation to other Geometry APIs, database structures
- **Affine Transform**
- **Linear Referencing operations**
- **Improved/Extended Spatial Indexes**
  - Updatable Quadtree, R-tree, Visitor pattern, performance…
- **Coverage datatype**