

JTS Topology Suite

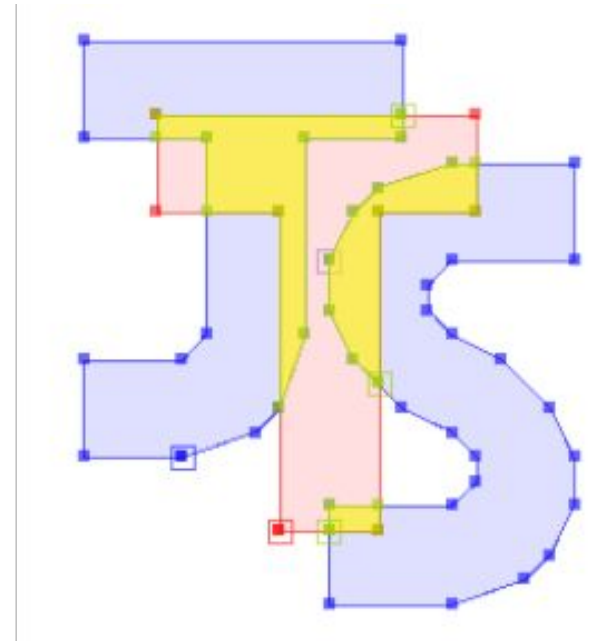
A Library for Geometry Processing

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JTS Topology Suite

- **Core API for processing Geometry**
- **Full implementation of *OpenGIS Consortium Simple Features for SQL* specification**
- **100% Java, Open Source (LGPL)**
- **750+ classes, 66K LOC**
- **Design Features:**
 - Fast
 - Robust
 - Complete
- **History**
 - Version 1.0 released Feb 2002
 - Version 1.11 released March 2010
 - Version 1.12 due Q1 2011

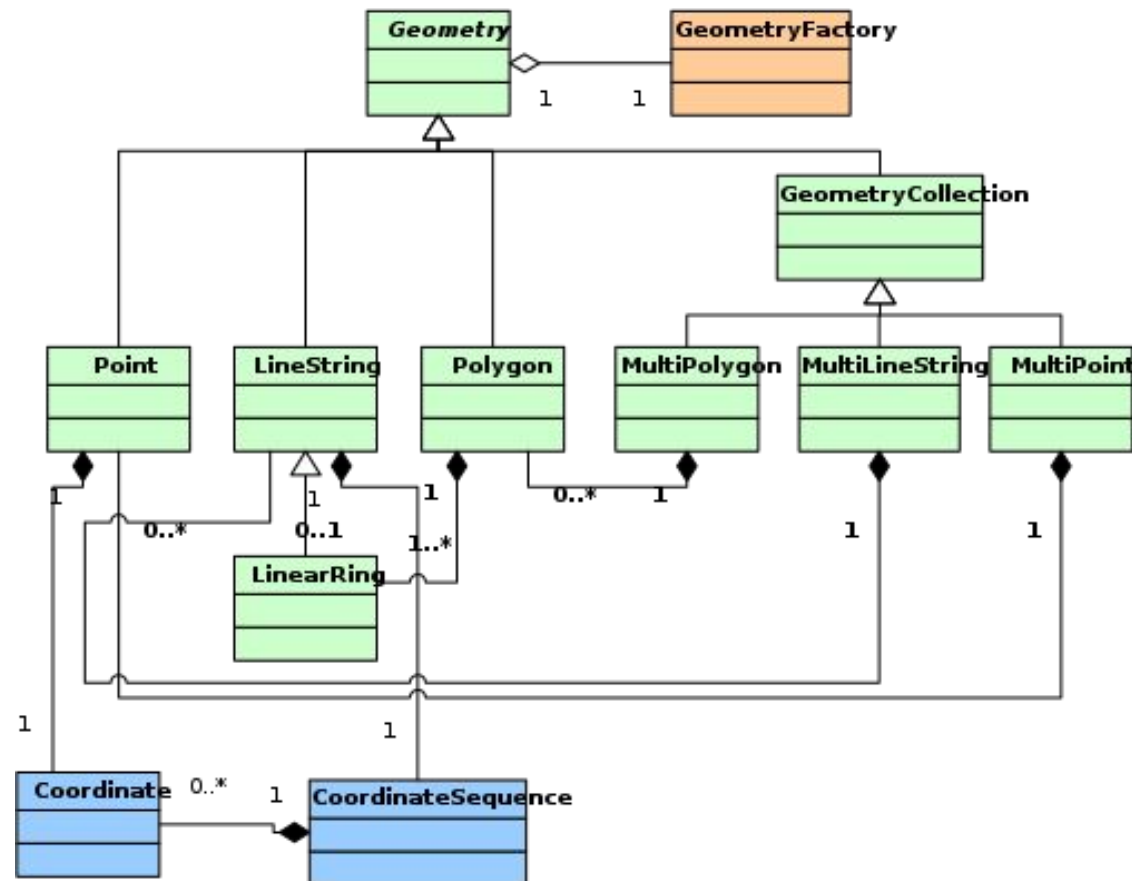
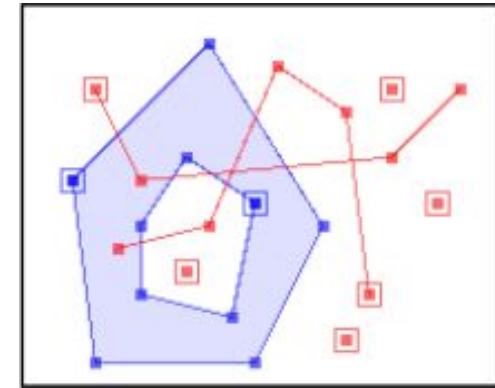


Geometry Model

- **Complete model for 2-D linear geometry (OGC SFS model)**

- Point
- LineString, LinearRing
- Polygon (with holes)
- MultiPoint, MultiLineString, MultiPolygon
- GeometryCollection

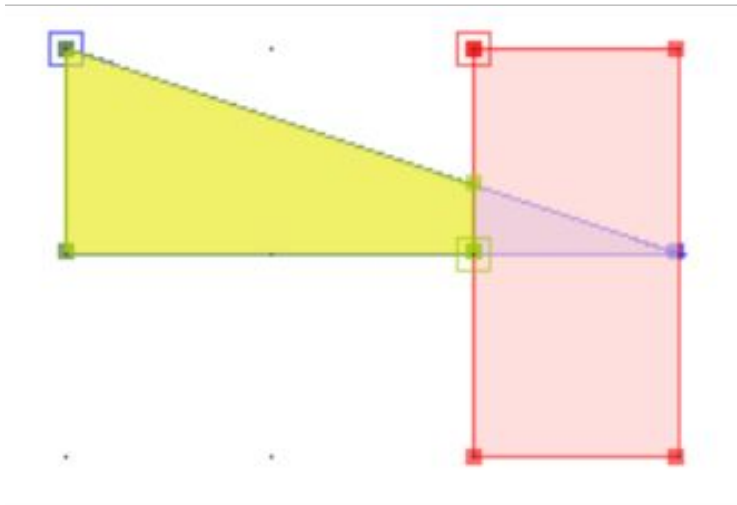
- **User-defined coordinate representation**



Explicit Precision Model

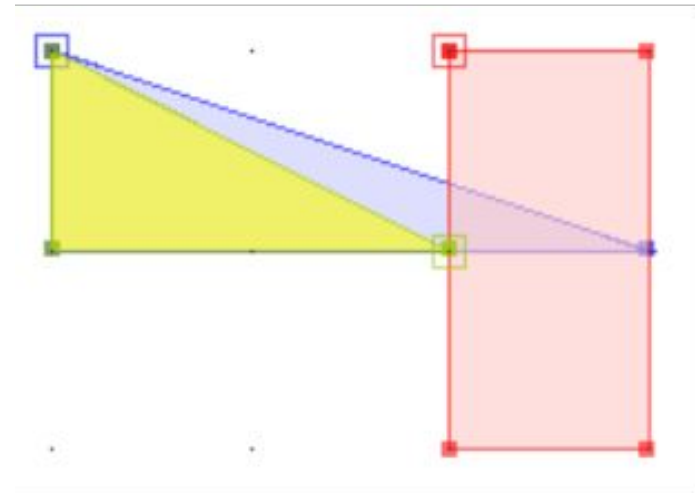
- Provides ability to specify Precision Model of coordinates
 - Floating - Double & Single Precision (IEEE-754)
 - Fixed - specified # of decimal places
- Ensures constructive geometry operations are closed over the specified coordinate space

Floating



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

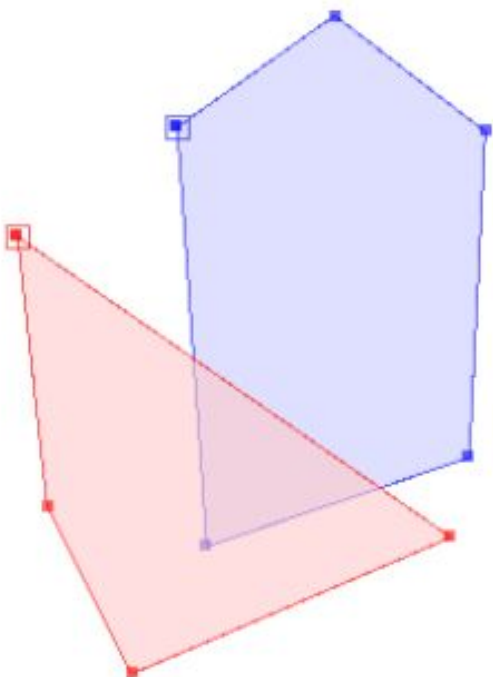
Fixed



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

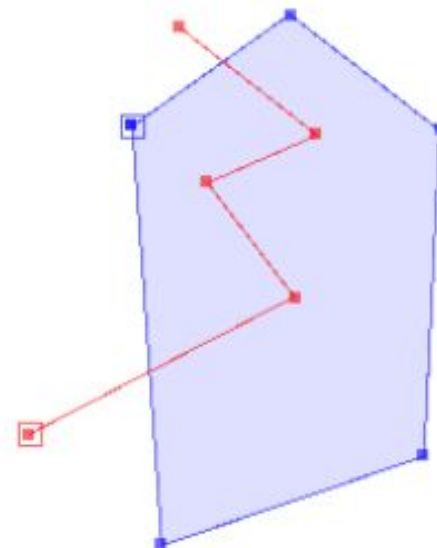
Spatial Predicates

- Computes the spatial relationship of two Geometries
- Implements the *Dimensionally Extended 9-Intersection Model (DE-9IM)*
 - Computes dimension of intersection of Interior, Boundary, Exterior
- General function
 - `relate(IMpattern)`
- Named predicates
 - intersects, contains, within, equals, disjoint, touches, crosses, overlaps, covers, coveredBy



		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

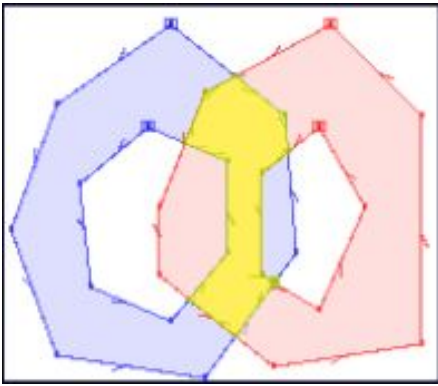


		B		
		Int	Bdy	Ext
A	Int	1	F	2
	Bdy	0	F	1
	Ext	1	0	2

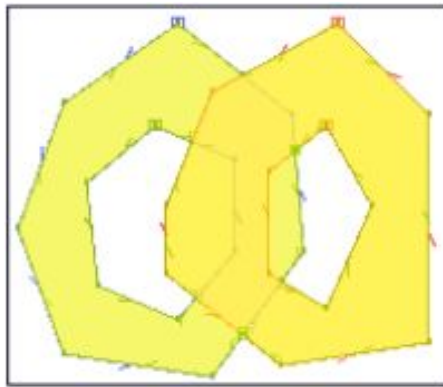
Binary Predicates		
	AB	BA
Equals	F	F
Disjoint	F	F
Intersects	T	T
Touches	F	F
Crosses	T	T
Within	F	F
Contains	F	F
Overlaps	F	F

Overlay Methods

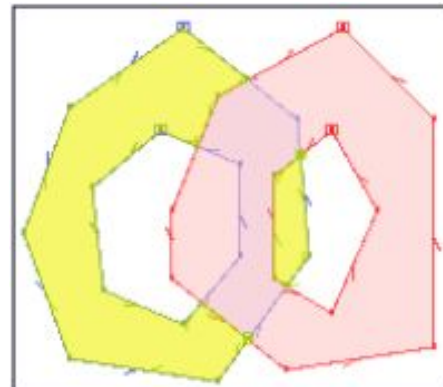
- AKA Boolean functions, Set-theoretic functions



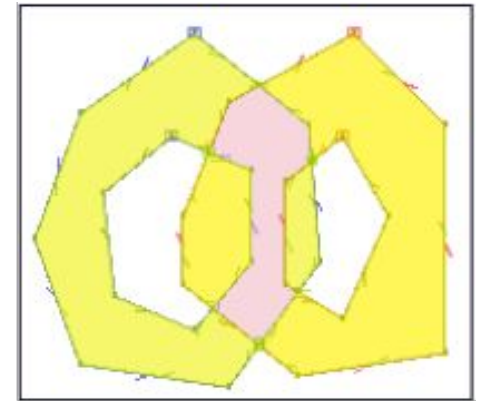
Intersection



Union

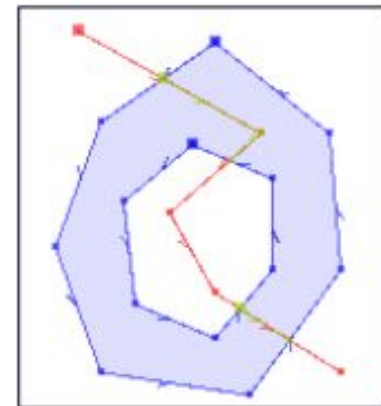


Difference



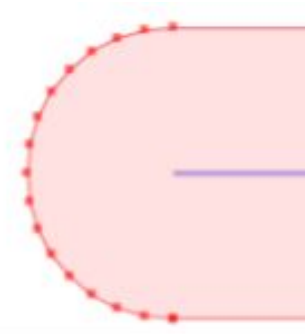
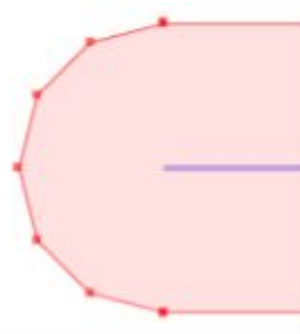
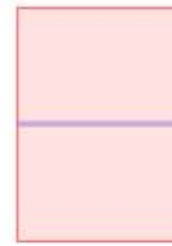
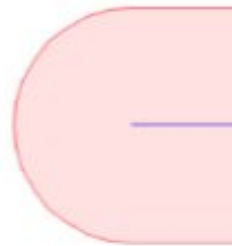
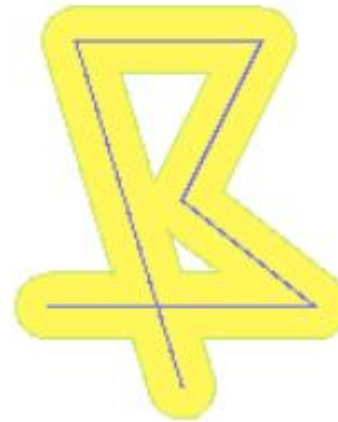
Symmetric Difference

- Heterogeneous – all geometry types supported



Buffering

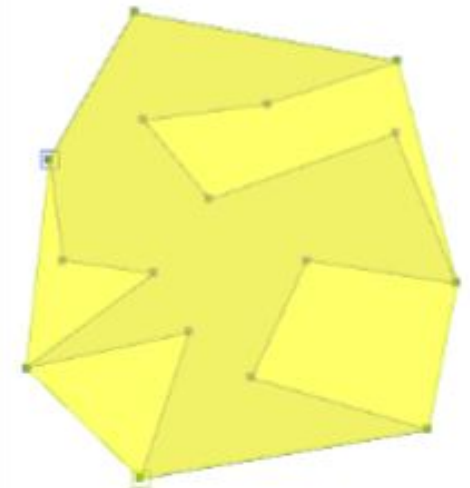
- **Positive & Negative buffers**
 - **All Geometry types**
 - **Robust, efficient algorithm**
- **Choice of End Cap Styles**
 - **Round, Square, Butt**
- **Curve Densification is user-controllable**



Other Constructive Methods

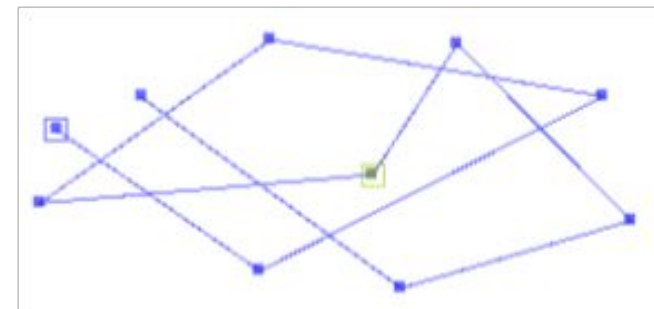
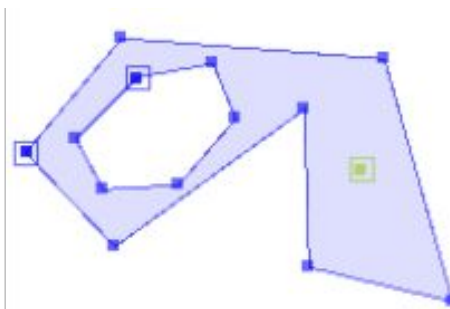
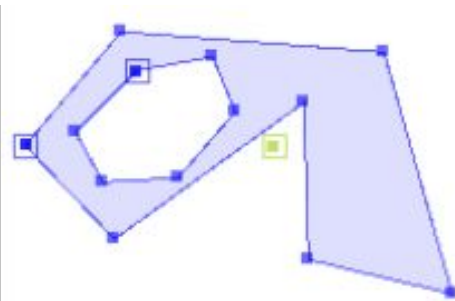
● Convex Hull

- 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



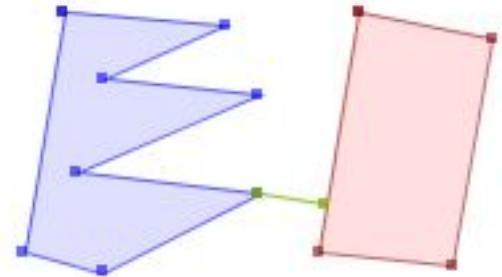
Metric Methods

- **Area, Length**

- Length = Perimeter, for Area geometries

- **Distance**

- Constructive – computes location of points providing minimum distance

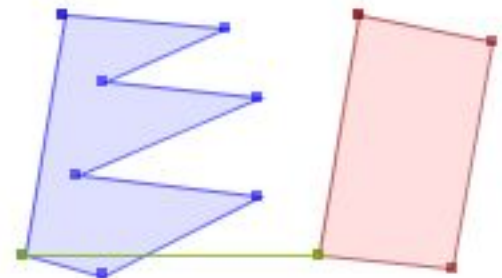


- **WithinDistance**

- “Limited predicate” allows optimized computation

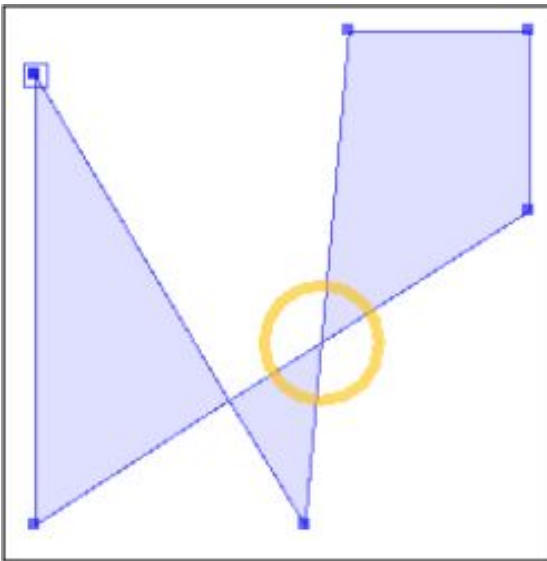
- **Hausdorff Distance**

- "How far apart"

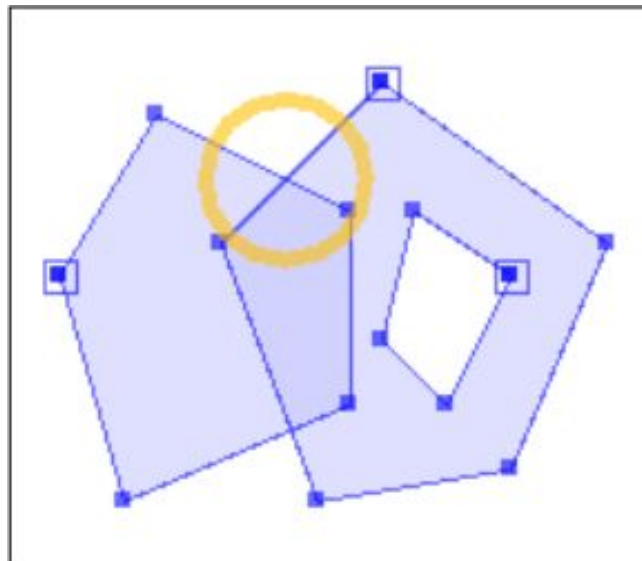


Geometry Validation

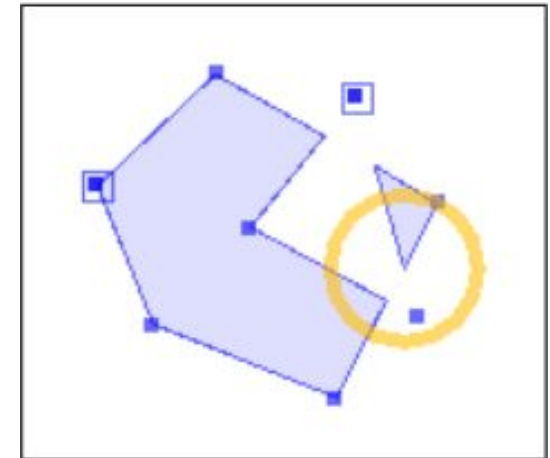
- **Validation of Geometry topology essential to ensure correct spatial processing**
 - Polygons in particular – many possible invalid situations
- **JTS provides full Validation of Topology**
 - **isValid** provides simple good/bad test
 - **ValidOp** class provides detailed error information, including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



Self-intersection



Overlapping Rings

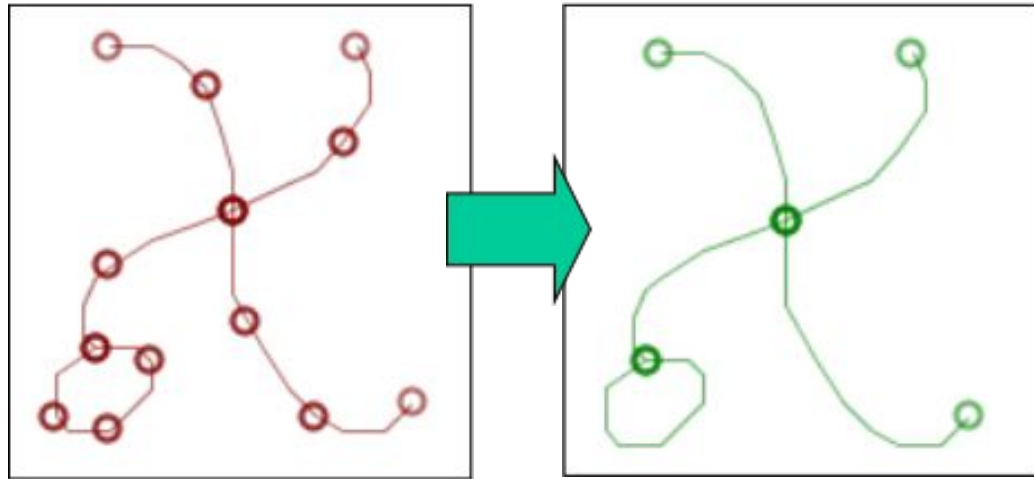


Hole intersects shell

Line Merging, Polygonization

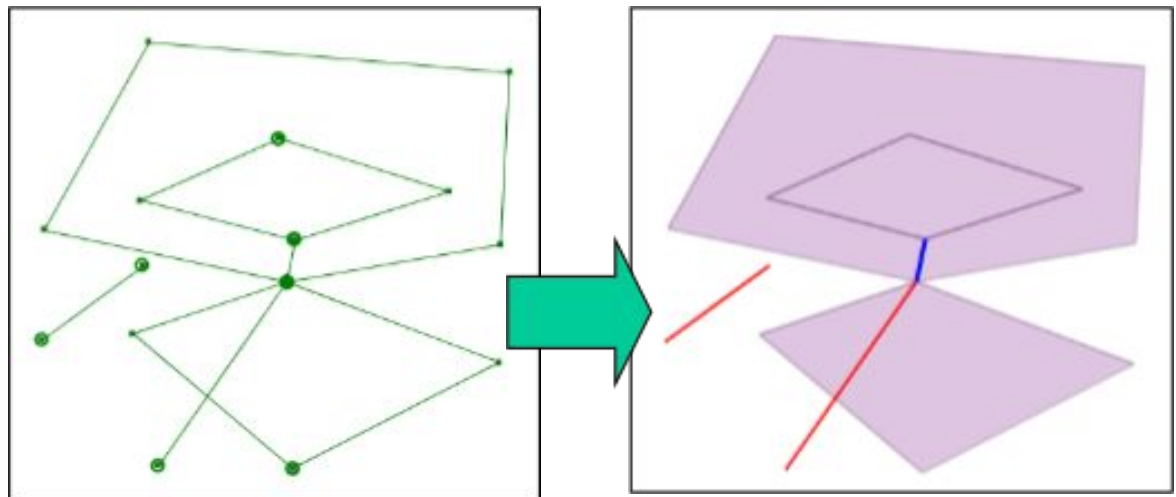
- **Line Merging**

- Removes
2-nodes from set
of LineStrings



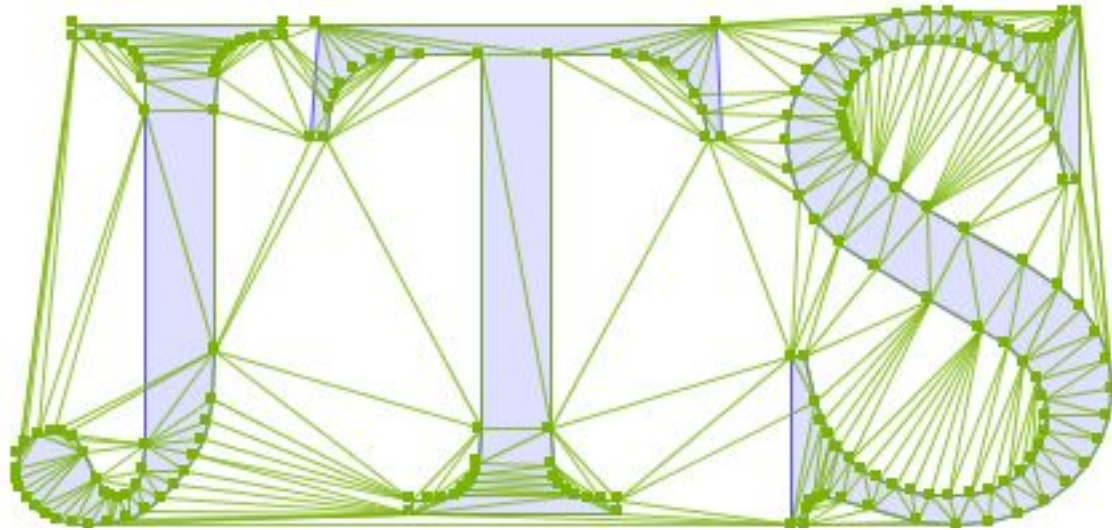
- **Polygonization**

- Finds errors
(Dangles, Cutlines)

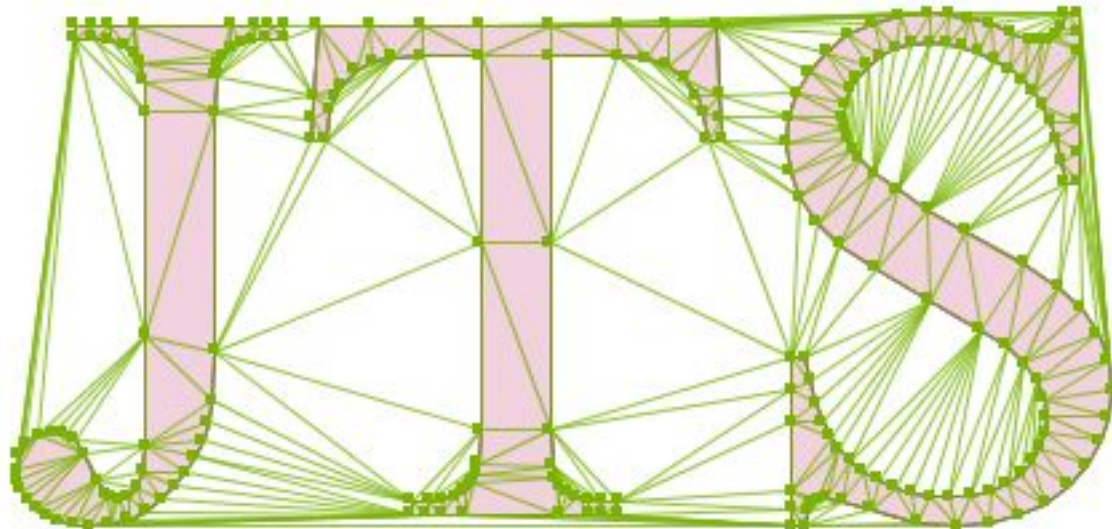


Delaunay Triangulation

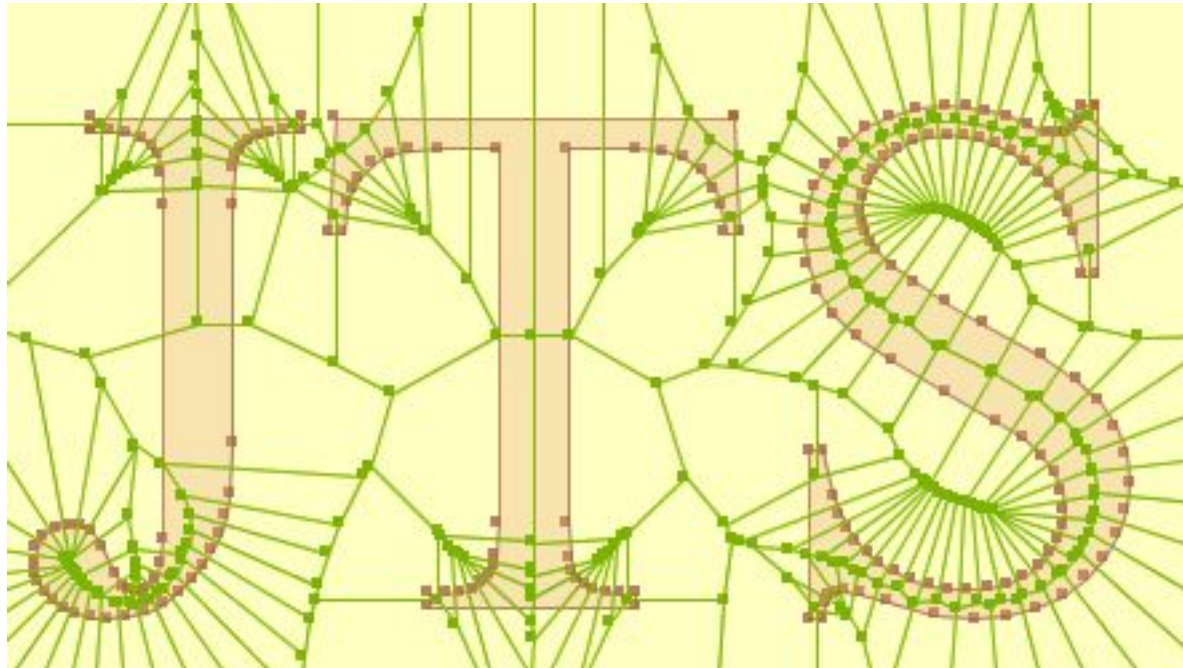
- Delaunay Triangulation



- Conforming Delaunay Triangulation



Voronoi Diagram



- **AKA Thiessen Polygons**

Spatial Algorithms & Structures

- **Numerous fundamental CG algorithms**

- Line segment intersection, Ring orientation, Point-Line orientation, Point-line distance, etc.

- **Spatial Indexes**

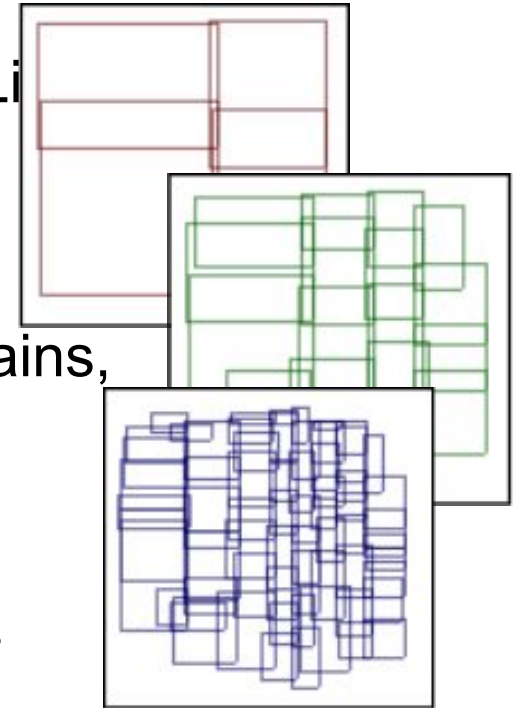
- Quadtree, STRtree, kD-tree, Bintree, MonotoneChains, SweepLine

- **Line segment Noding**

- find/create all intersections in set of Line Segments
- Snap-Rounding

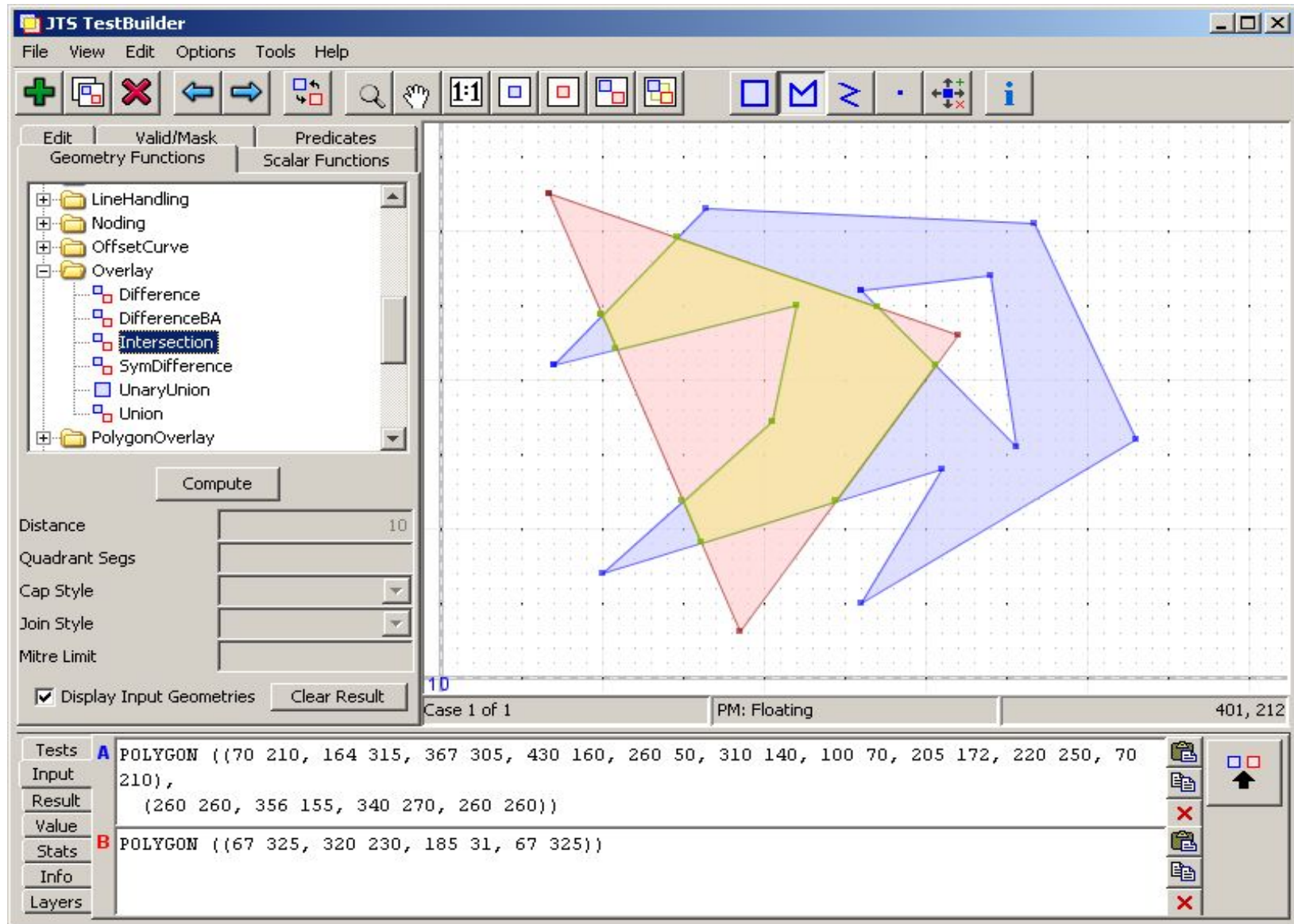
- **Planar Graph framework**

- **Precision Reduction**



JTS TestBuilder

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



JTS In Use

- **JTS used for geometry processing in numerous open source and commercial geospatial 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...