The jGraphT library

Tecniche di Programmazione – A.A. 2015/2016

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Summary

- The JGraphT library
- Creating graphs
- Visits in JGraphT

Introduction to jGraphT

The jGraphT library

JGraphT

- http://jgrapht.org
  - (do not confuse with jgraph.com)
- Free Java graph library that provides graph objects and algorithms
- Easy, type-safe and extensible thanks to <generics>
- Just add **`jgrapht-core-0.9.0.jar`** to your project

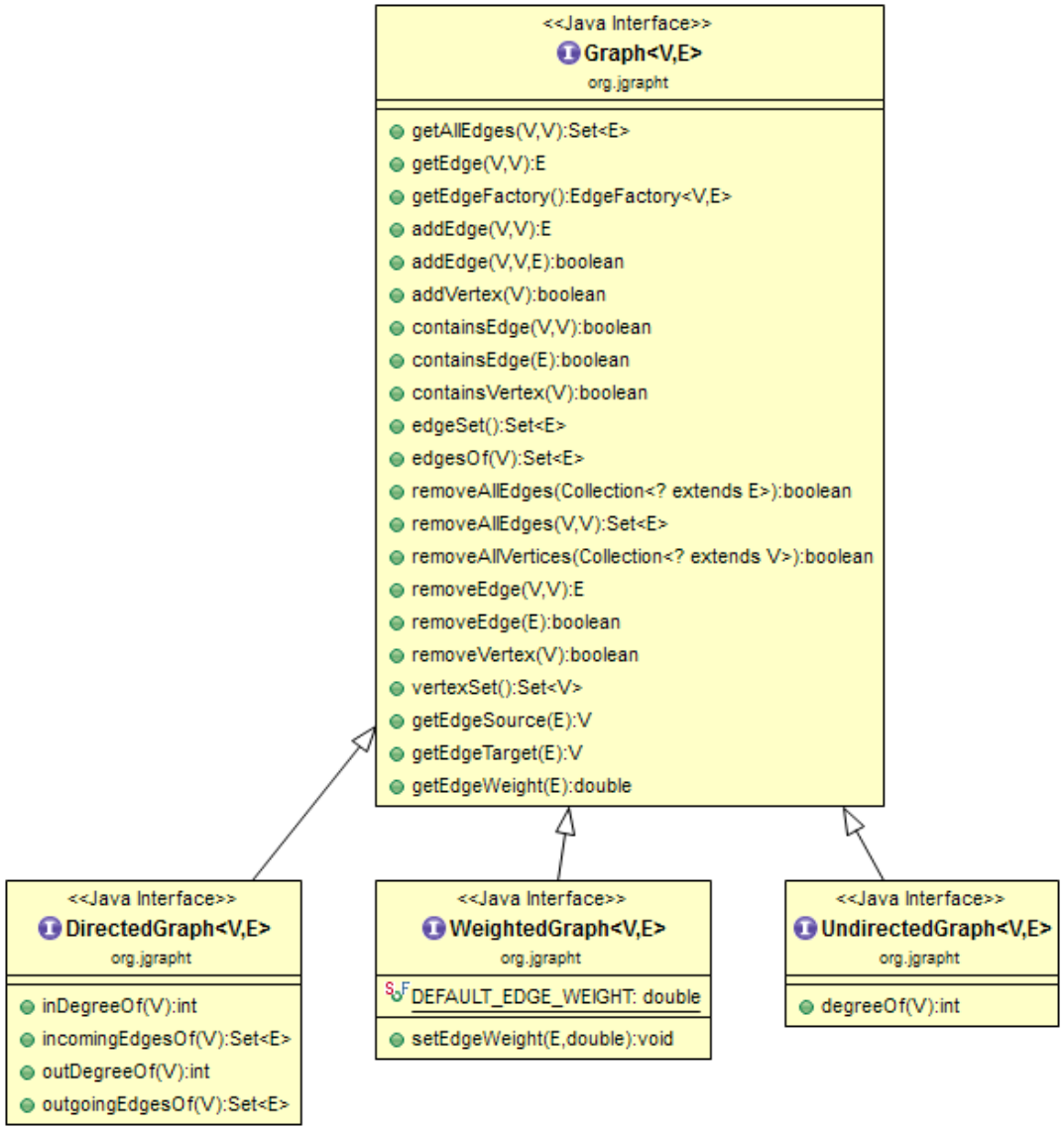
JGraphT structure

Packages	
org.jgrapht	The front-end API's interfaces and classes, including Graph, DirectedGraph and UndirectedGraph.
org.jgrapht.alg	Algorithms provided with JGraphT.
org.jgrapht.alg.util	Utilities used by JGraphT algorithms.
org.jgrapht.demo	Demo programs that help to get started with JGraphT.
org.jgrapht.event	Event classes and listener interfaces, used to provide a change notification mechanism on graph modification events.
org.jgrapht.ext	Extensions and integration means to other products.
org.jgrapht.generate	Generators for graphs of various topologies.
org.jgrapht.graph	Implementations of various graphs.
org.jgrapht.traverse	Graph traversal means.
org.jgrapht.util	Non-graph-specific data structures, algorithms, and utilities used by JGraphT.

Graph objects

- All graphs derive from
  - Interface `Graph<V,E>`
  - V = type of vertices
  - E = type of edges
    - usually `DefaultEdge` or `DefaultWeightedEdge`
- Main interfaces
  - `DirectedGraph<V,E>`
  - `UndirectedGraph<V,E>`
  - `WeightedGraph<V,E>`

JGraphT main interfaces



Graph classes

org.jgrapht

Graph (I)

DirectedGraph (I)

UndirectedGraph (I)

WeightedGraph (I)

org.jgrapht.graphs

SimpleGraph

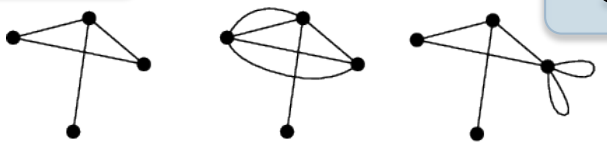
SimpleWeightedGraph

SimpleDirectedGraph

SimpleDirectedWeightedGraph

DefaultDirectedGraph

DefaultDirectedWeightedGraph



simple graph *multigraph* *pseudograph*

DirectedMultigraph

Multigraph

DirectedWeightedMultigraph

WeightedMultigraph

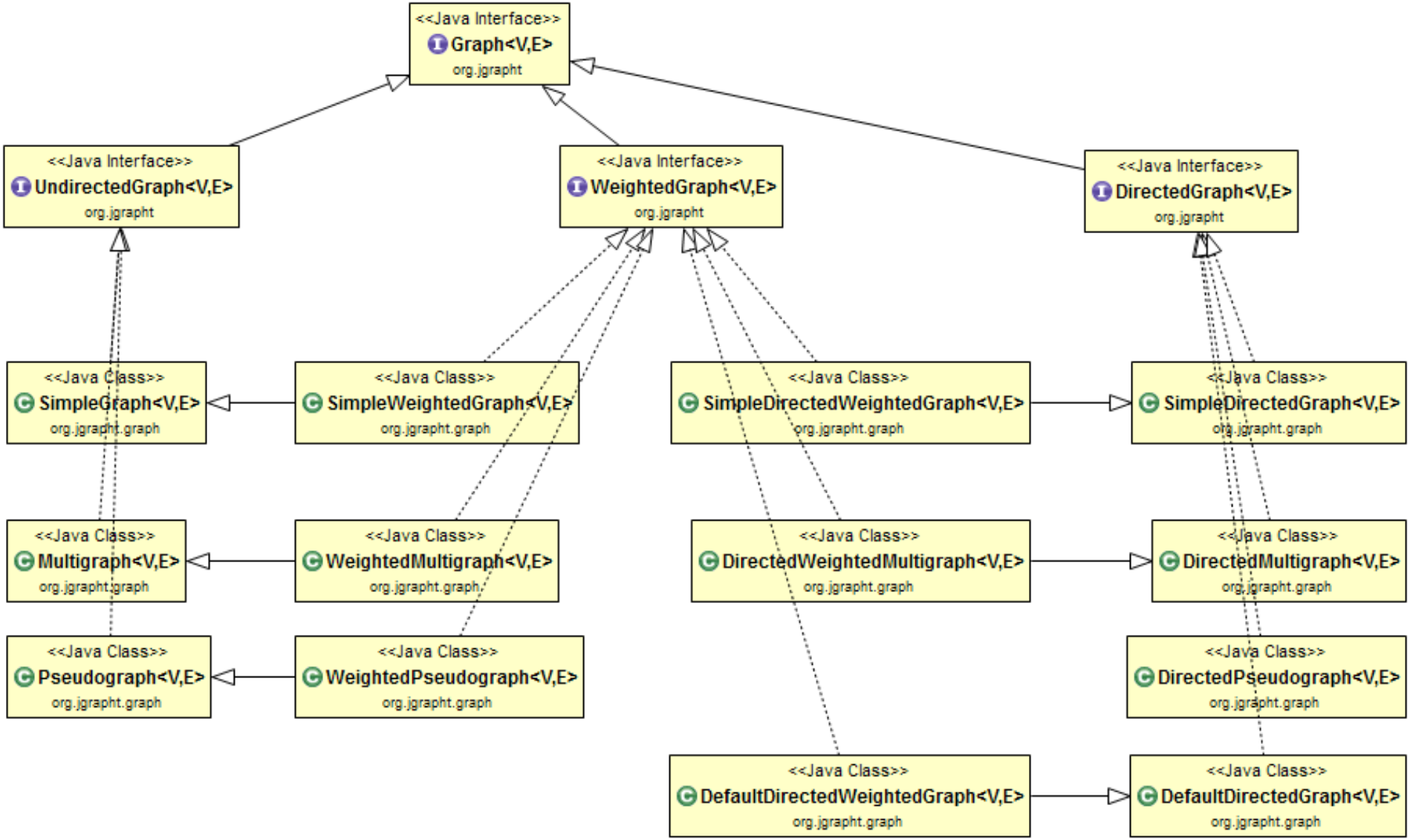
DirectedPseudograph

DirectedWeightedPseudograph

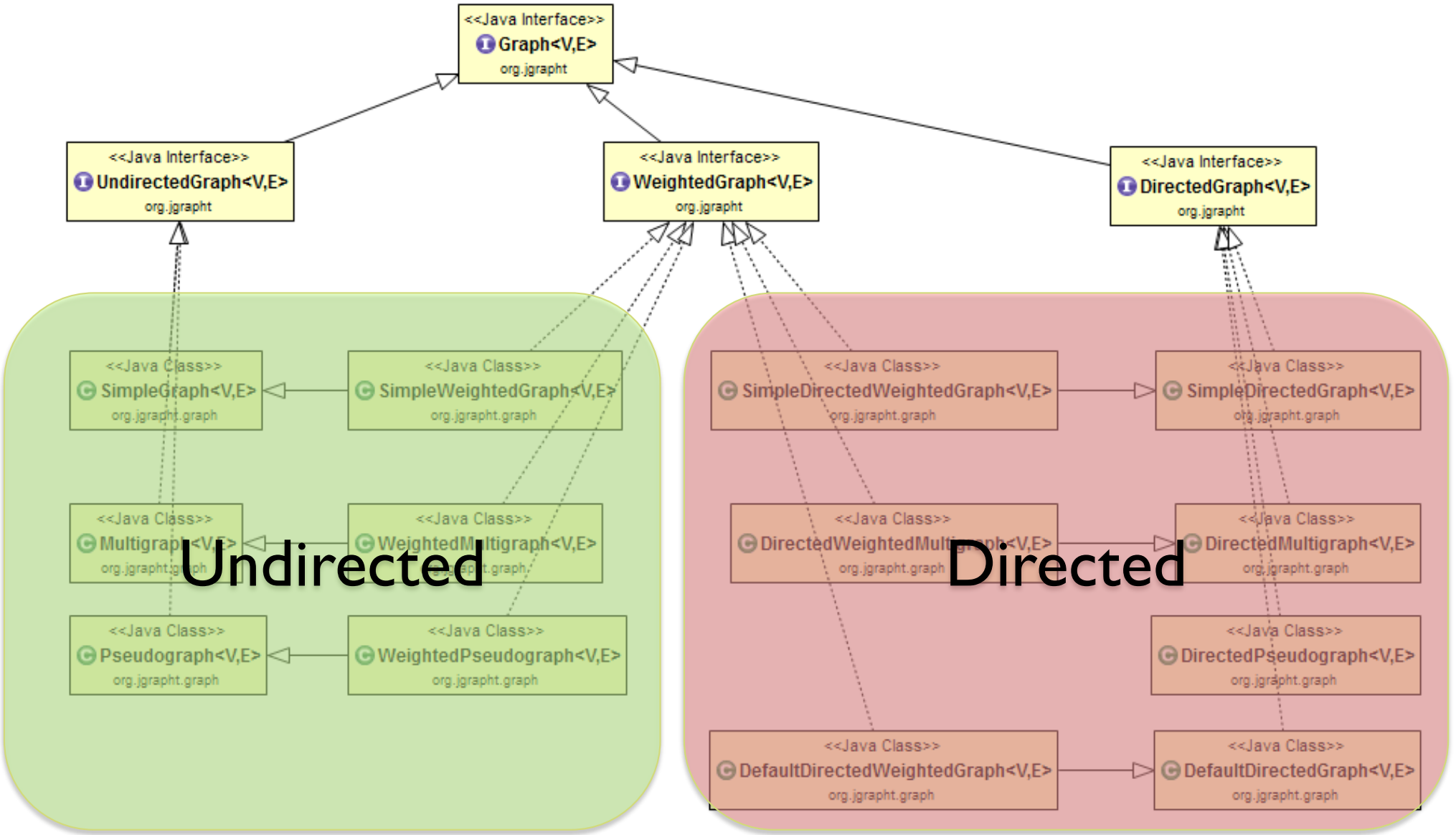
Pseudograph

WeightedPseudograph

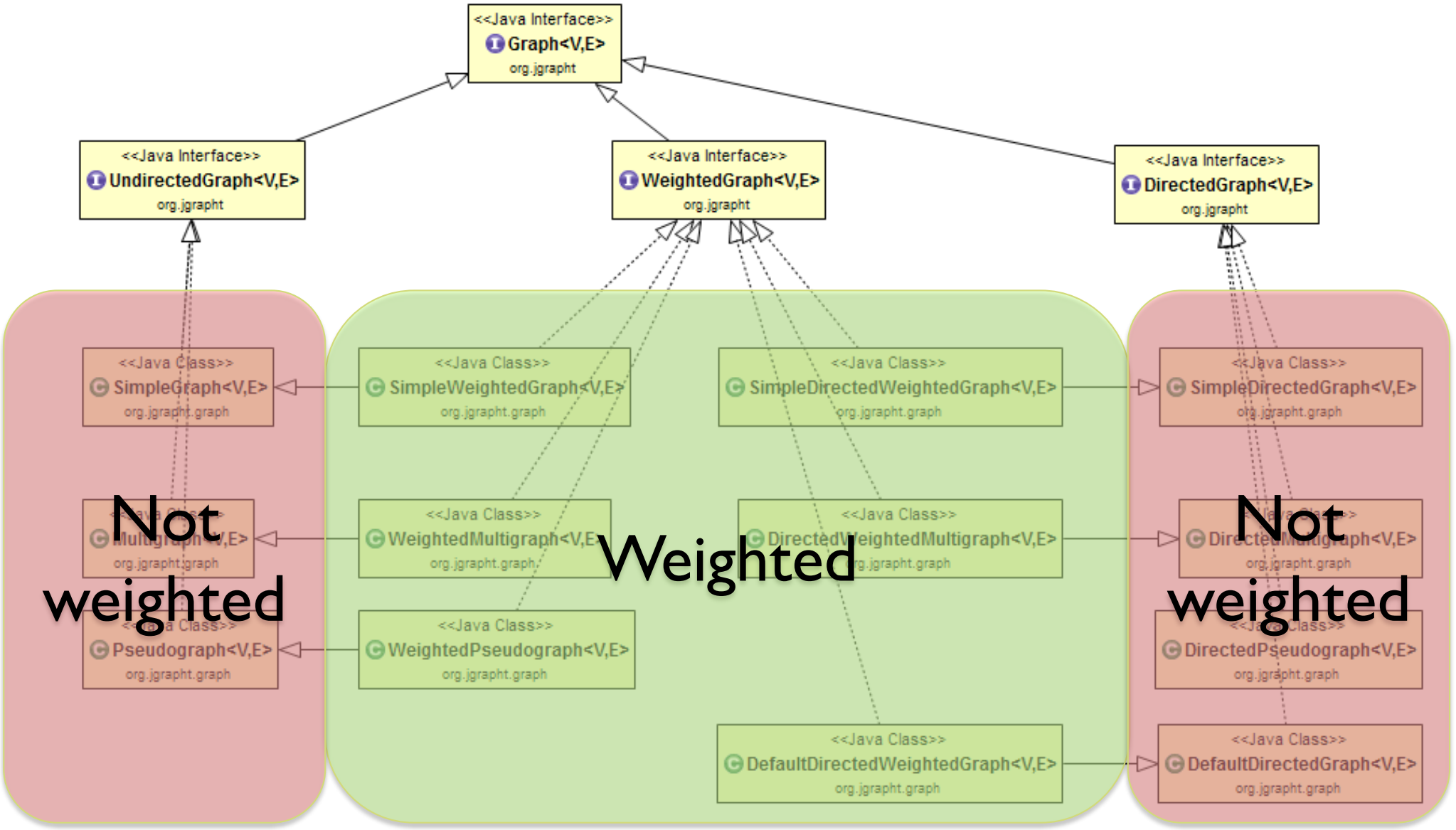
Graph classes



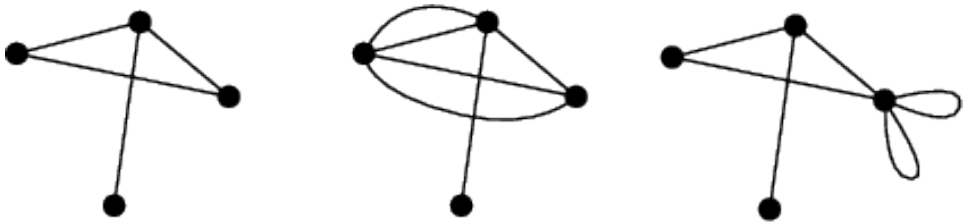
Graph classes



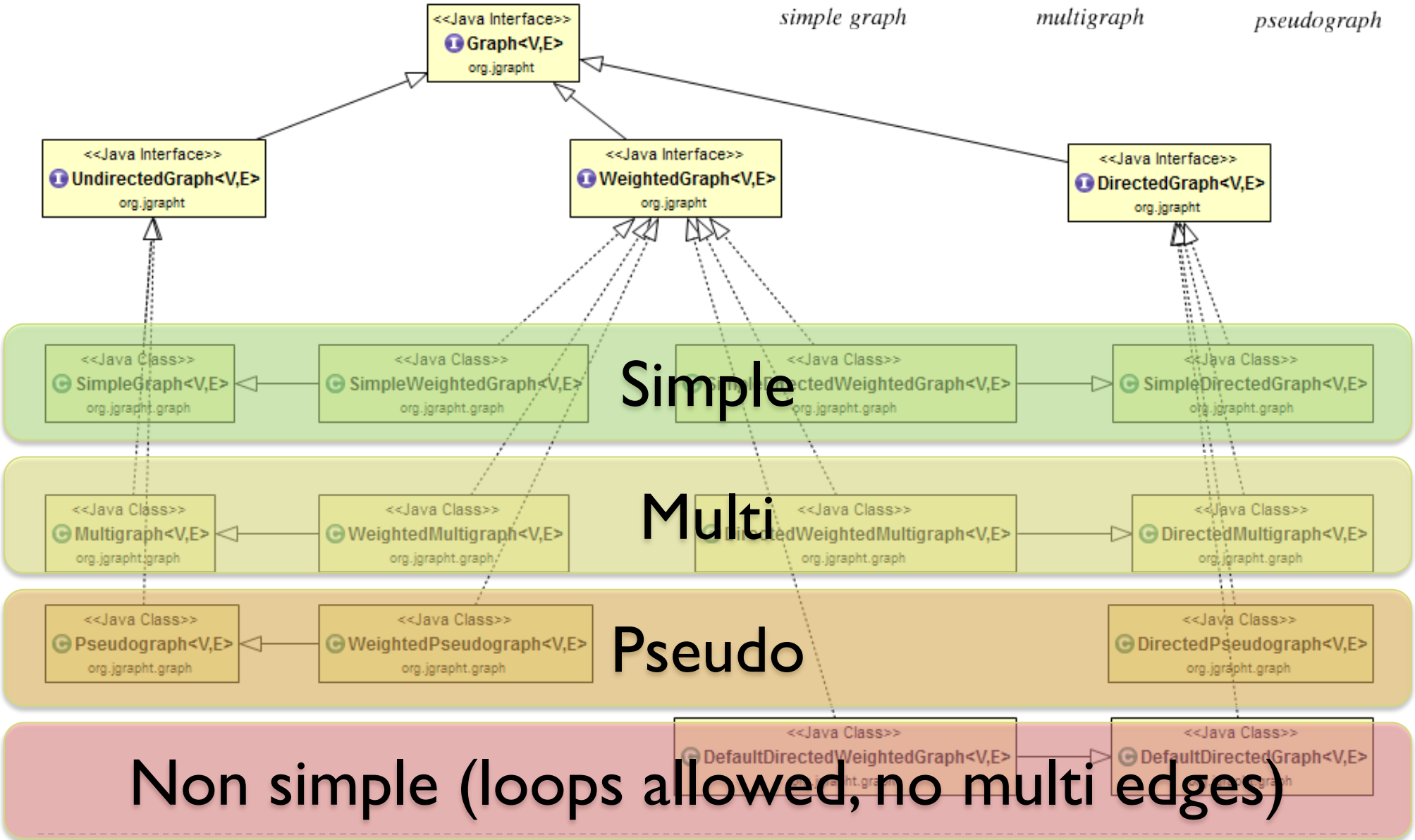
Graph classes



Graph classes



simple graph *multigraph* *pseudograph*



Creating graphs

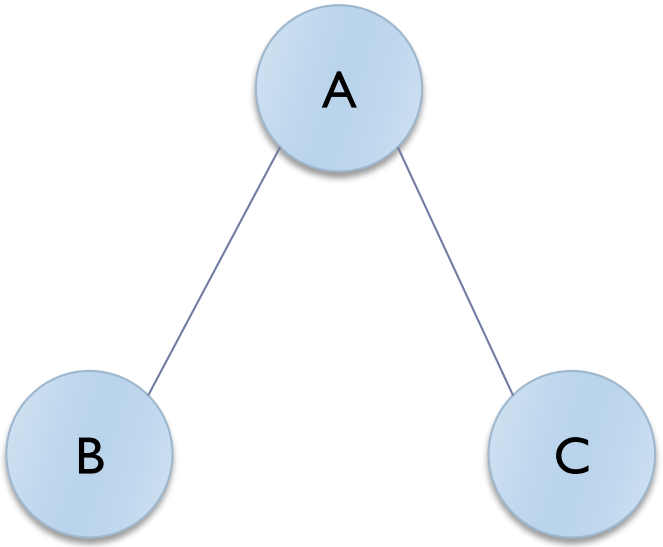
The jGraphT library

Creating graphs

- Construct your desired type of graph
- Add vertices
  - boolean **addVertex**(V v)
- Add edges
  - E **addEdge**(V sourceVertex, V targetVertex)
  - boolean **addEdge**(V sourceVertex, V targetVertex, E e)
  - void **setEdgeWeight**(E e, double weight)
- Print graph (for debugging)
  - toString()
- Warning: E and V should correctly implement .equals() and .hashCode()

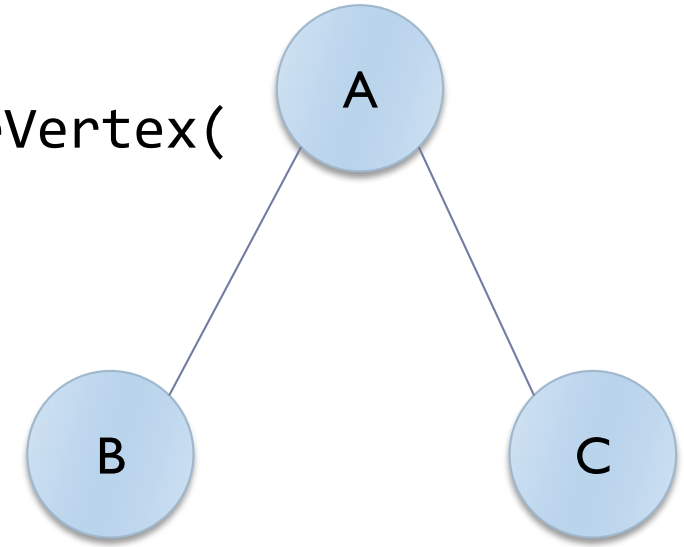
Example

```
UndirectedGraph<String, DefaultEdge> graph = new
SimpleGraph<>(DefaultEdge.class) ;

graph.addVertex("A") ;
graph.addVertex("B") ;
graph.addVertex("C") ;

graph.addEdge("A", "B") ;
graph.addEdge("A", "C") ;
```

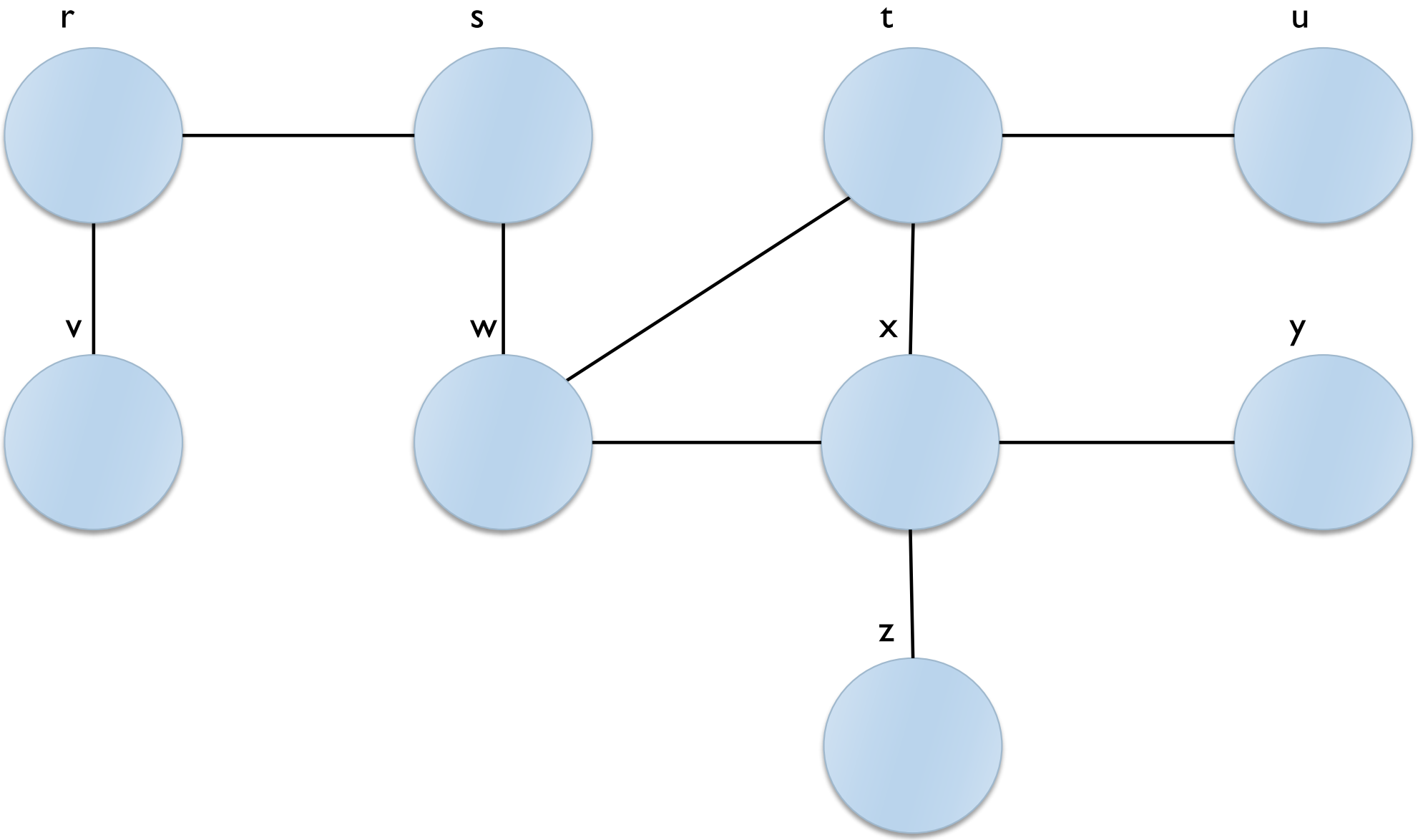


Example

```
for( String s: graph.vertexSet() ) {
        System.out.println("Vertex "+s) ;
        for( DefaultEdge e: graph.edgesOf(s) ) {
                System.out.println("Degree: “
                        +graph.degreeOf(s)) ;
                System.out.println(
                        Graphs.getOppositeVertex(
                        graph, e, s)) ;
        }
}
```



Example



For testing…

Package org.jgrapht.generate

Generators for graphs of various topologies.

See:

Description

Interface Summary	
GraphGenerator<V,E,T>	GraphGenerator defines an interface for generating new graph structures.
RandomGraphGenerator.EdgeTopologyFactory<VV,EE>	This class is used to generate the edge topology for a graph.

Class Summary	
CompleteBipartiteGraphGenerator<V,E>	Generates a complete bipartite graph of any size.
CompleteGraphGenerator<V,E>	Generates a complete graph of any size.
EmptyGraphGenerator<V,E>	Generates an empty graph of any size.
GridGraphGenerator<V,E>	Generates a bidirectional grid graph of any size.
HyperCubeGraphGenerator<V,E>	Generates a hyper cube graph of any size.
LinearGraphGenerator<V,E>	Generates a linear graph of any size.
RandomGraphGenerator<V,E>	This Generator creates a random-topology graph of a specified number of vertexes and edges.
RingGraphGenerator<V,E>	Generates a ring graph of any size.
ScaleFreeGraphGenerator<V,E>	Generates directed or undirected scale-free network of any size.
StarGraphGenerator<V,E>	Generates a star graph of any size.
WheelGraphGenerator<V,E>	Generates a wheel graph of any size.

Example

Presentazione del corso
Guida dello studente

Percorso Generalista
Orientamento "Information technology engineering" - Shanghai

Percorso Generalista

Top

1° anno

Periodo	Codice	Lingua	Insegnamento	Crediti	Docente	Note	Vincoli
1	16ACFOA	IT	Analisi matematica I	10	A. Tabacco E. Serra F. Ceragioli ...		
1	15AHMOA	IT	Chimica	8	B. Onida S. Ronchetti E. Angelini ...		
1	07LKIOA	IT	Lingua inglese I livello	3			
2			Crediti liberi del 1 anno	6			
2	17AXOOA	IT	Fisica I	10	M. Agnello A. Montorsi A. Gamba ...		
2	17BCGOA	IT	Geometria	10	M. Ferrarotti C. Massaza J. Cordovez Manriquez ...		
2	12BHDOA	IT	Informatica	8	P. Laface A. Acquaviva L. Sterpone ...		

2° anno

Periodo	Codice	Lingua	Insegnamento	Crediti	Docente	Note	Vincoli
1	02MNOOA	IT	Algoritmi e programmazione	10	P. Camurati		Si
1	23ACIOA	IT	Analisi matematica II	8	L. Scuderi S. Rolando		Si
1	01AULOA	IT	Elettrotecnica	10	F. Corinto		Si
1	03AXPOA	IT	Fisica II	6	M. Pretti		Si
2	12AGAOA	IT	Calcolatori elettronici	8	M. Sonza Reorda		Si
2	05BQXOA	IT	Metodi matematici per l'ingegneria	10	D. Bazzanella V. Recupero		Si
2	02NVAOA	IT	Sistemi e tecnologie elettroniche	10	F. Bonani		Si

3° anno

Periodo	Codice	Lingua	Insegnamento	Crediti	Docente	Note	Vincoli
1	03MOAOA	IT	Elettronica applicata e misure	10	D. Del Corso		Si
1	12CDUOA	IT	Reti di calcolatori	8	G. Marchetto		Si
1	05CJCOA	IT	Sistemi operativi	6	S. Quer		Si
1	01MOOOA	IT	Teoria ed elaborazione dei segnali	10	G. Bosco		Si
1,2	26IBNOA	IT	Prova finale	1			
1,2	11CWHOA	IT	Tirocinio	12	C. Passerone		Si
1,2	02CWHOA	IT	Tirocinio	10	C. Passerone	(1)(2)	Si
2	04AFQOA	IT	Basi di dati	6	S. Chiusano		Si
2	18AKSOA	IT	Controlli automatici	10	M. Taragna		Si
2			Crediti liberi del 3 anno	6			
2	05CBIOA	IT	Programmazione a oggetti	6	G. Bruno		Si

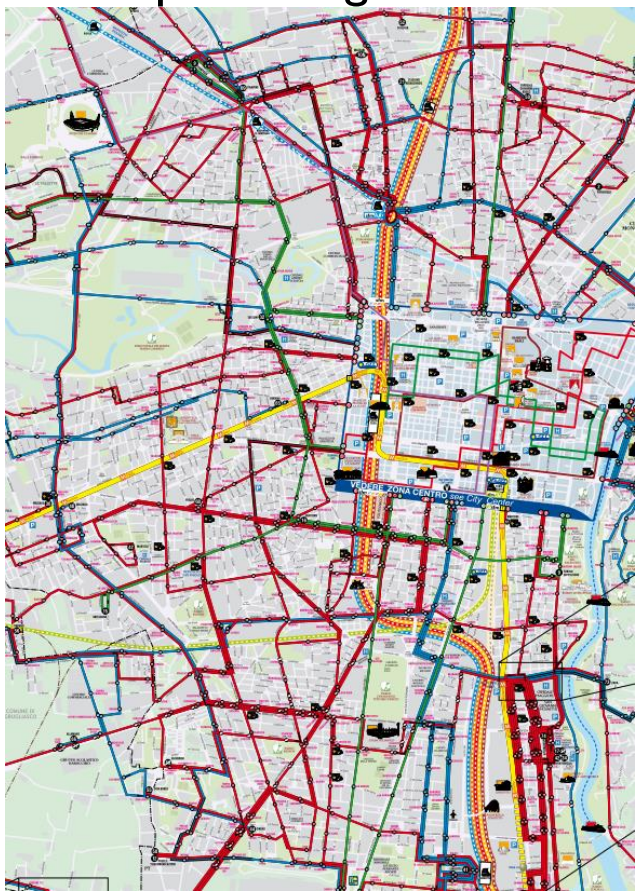
Crediti liberi del 1 anno

Periodo	Codice	Lingua	Insegnamento	Crediti	Docente	Note	Vincoli
2	01DDVOA	EN	Automotive evolution	6	G. Genta	(4)	Si
2	01OHOOA	IT	Chimica sperimentale per l'ingegneria	6	M. Pedazzi	(4)	Si
2	01OQCOA	IT	Etica	6	M. Ghisleni	(4)	Si

https://didattica.polito.it/pls/portal30/gap.a_mds.espandi2?p_aa_acc=2013&p_sdu=37&p_cds=3&p_header=&p_lang=IT

Example: Turin public transportation

http://www.gtt.to.it/



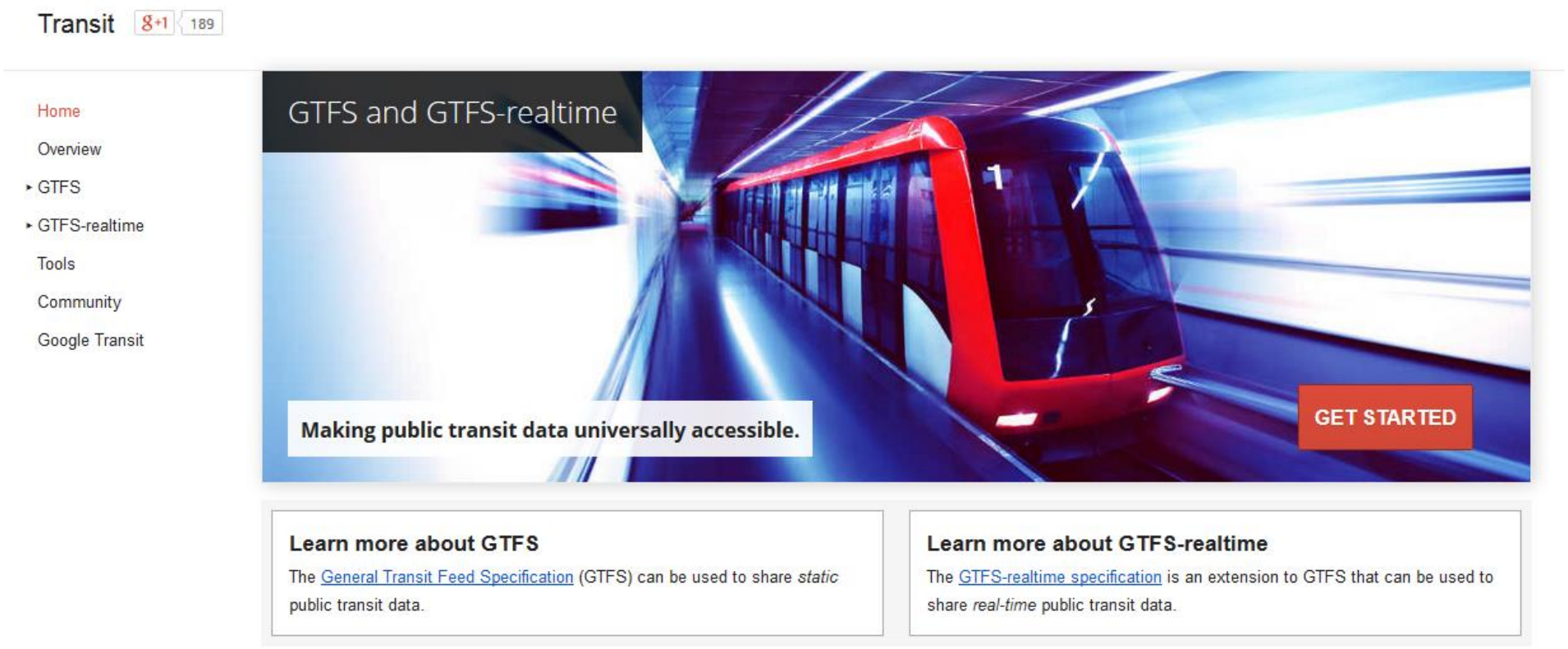
GRUPPO TORINESE TRASPORTI

http://www.sfmtorino.it/

REGIONE PIEMONTE
sfm
servizio ferroviario metropolitano

Google's GTFS standard

https://developers.google.com/transit/



GTFS Specification

Filename	Required	Defines
agency.txt	Required	One or more transit agencies that provide the data in this feed.
stops.txt	Required	Individual locations where vehicles pick up or drop off passengers.
routes.txt	Required	Transit routes. A route is a group of trips that are displayed to riders as a single service.
trips.txt	Required	Trips for each route. A trip is a sequence of two or more stops that occurs at specific time.
stop_times.txt	Required	Times that a vehicle arrives at and departs from individual stops for each trip.
calendar.txt	Required	Dates for service IDs using a weekly schedule. Specify when service starts and ends, as well as days of the week where service is available.
calendar_dates.txt	Optional	Exceptions for the service IDs defined in the calendar.txt file. If calendar_dates.txt includes ALL dates of service, this file may be specified instead of calendar.txt.
fare_attributes.txt	Optional	Fare information for a transit organization's routes.
fare_rules.txt	Optional	Rules for applying fare information for a transit organization's routes.
shapes.txt	Optional	Rules for drawing lines on a map to represent a transit organization's routes.
frequencies.txt	Optional	Headway (time between trips) for routes with variable frequency of service.
transfers.txt	Optional	Rules for making connections at transfer points between routes.
feed_info.txt	Optional	Additional information about the feed itself, including publisher, version, and expiration information.

https://developers.google.com/transit/gtfs/reference

Where to find data?

GTT GRUPPO TORINESE TRASPORTI

http://opendata.5t.torino.it/gtfs/torino_it.zip

REGIONE PIEMONTE sfm servizio ferroviario metropolitano

http://opendata.5t.torino.it/gtfs/sfm_torino_it.zip

Need more?

http://www.gtfs-data-exchange.com/

Querying graph structure

- Navigate structure
  - java.util.Set<V> **vertexSet**()
  - boolean **containsVertex**(V v)
  - boolean **containsEdge**(V sourceVertex,V targetVertex)
  - java.util.Set<E> **edgesOf**(V vertex)
  - java.util.Set<E> **getAllEdges**(V sourceVertex,V targetVertex)
- Query Edges
  - V **getEdgeSource**(E e)
  - V **getEdgeTarget**(E e)
  - double **getEdgeWeight**(E e)

Utility functions

- Static class **org.jgrapht.Graphs**
- Easier creation
  - public static <V,E> E **addEdge**(Graph<V,E> g,V sourceVertex, V targetVertex, double weight)
  - public static <V,E> E **addEdgeWithVertices**(Graph<V,E> g, V sourceVertex,V targetVertex)
- Easier navigation
  - public static <V,E> java.util.List<V> **neighborListOf**(Graph<V,E> g, V vertex)
  - public static String **getOppositeVertex**(Graph<String, DefaultEdge> g, DefaultEdge e, String v)
  - public static <V,E> java.util.List<V> **predecessorListOf**(DirectedGraph<V,E> g,V vertex)
  - public static <V,E> java.util.List<V> **successorListOf**(DirectedGraph<V,E> g,V vertex)

Visits in JGraphT

Representing and visiting graphs

JGraphT and visits

- Visits are called "traversals"
- Implemented through **iterator** classes
- Package **org.jgrapht.traverse**

Graph traversal classes

Package org.jgrapht.traverse

Graph traversal means.

See:

Description

Interface Summary	
GraphIterator<V,E>	A graph iterator.

Class Summary	
AbstractGraphIterator<V,E>	An empty implementation of a graph iterator to minimize the effort required to implement graph iterators.
BreadthFirstIterator<V,E>	A breadth-first iterator for a directed and an undirected graph.
ClosestFirstIterator<V,E>	A closest-first iterator for a directed or undirected graph.
CrossComponentIterator<V,E,D>	Provides a cross-connected-component traversal functionality for iterator subclasses.
DepthFirstIterator<V,E>	A depth-first iterator for a directed and an undirected graph.
TopologicalOrderIterator<V,E>	Implements topological order traversal for a directed acyclic graph.

Graph iterators

- Usual hasNext() and next() methods
- May register event listeners to traversal steps
  - void **addTraversalListener**(TraversalListener<V,E> l)
- TraversalListeners may react to:
  - Edge traversed
  - Vertex traversed
  - Vertex finished
  - Connected component started
  - Connected component finished

Types of traversal iterators

- BreadthFirstIterator
- DepthFirstIterator
- ClosestFirstIterator
  - The metric for *closest* here is the path length from a start vertex. Graph.getEdgeWeight(Edge) is summed to calculate path length. Optionally, path length may be bounded by a finite radius.
- TopologicalOrderIterator
  - A topological sort is a permutation *p* of the vertices of a graph such that an edge {*i*,*j*} implies that *i* appears before *j* in *p*. Only directed acyclic graphs can be topologically sorted.

Resources

- JGraphT Library: http://jgrapht.org/

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