Tutorial: Large Scale Network Analytics with SNAP

http://snap.stanford.edu/proj/snap-www

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WWW-15, Florence, Italy **May, 2015**

Snap.py: SNAP for Python

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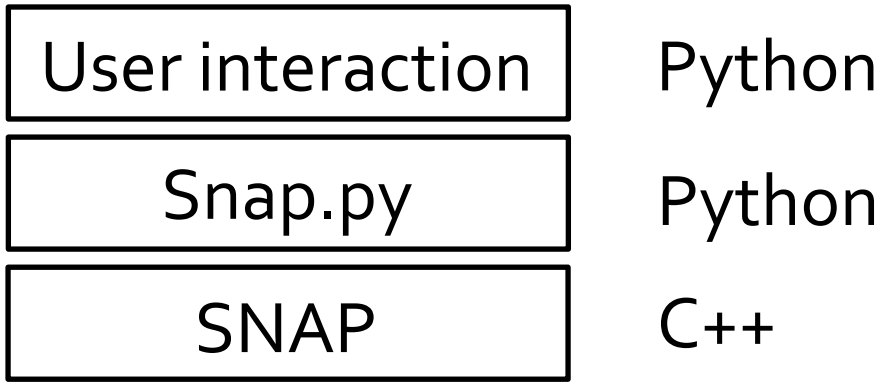
What is Snap.py?

- **Snap.py** (pronounced "snappy"):
  SNAP for Python

http://snap.stanford.edu/snappy



Solution	Fast Execution	Easy to use, interactive
C++	✓	
Python		✓
Snap.py (C++, Python)	✓	✓

Installing Snap.py

- **Requires Python 2.x**
  - **Download and install Python 2.x:**

    http://www.python.org
- **Download the Snap.py for your platform:**

    http://snap.stanford.edu/snappy
  - Packages for Mac OS X, Windows, Linux (CentOS)
    - OS must be 64-bit
    - Mac OS X, 10.7.5 or later
    - Windows, install Visual C++ Redistributable Runtime
      http://www.microsoft.com/en-us/download/details.aspx?id=30679
- **Installation:**
  - Follow instructions on the Snap.py webpage

```
python setup.py install
```

If you encounter problems, please report them to us or post to the mailing list

Snap.py: Important

- The most important step:

  Import the snap module!

```
$ python
>>> import snap
```

Snap.py Tutorial

- **On the Web:**
  http://snap.stanford.edu/snappy/doc/tutorial/index-tut.html
- **We will cover:**
  - Basic Snap.py data types
  - Vectors, hash tables and pairs
  - Graphs and networks
  - Graph creation
  - Adding and traversing nodes and edges
  - Saving and loading graphs
  - Plotting and visualization

Snap.py Naming Conventions (1)

Variable types/names:

- **…Int**: an integer operation, variable: **GetValInt()**
- **…Flt**: a floating point operation, variable; **GetValFlt()**
- **…Str**: a string operation, variable; **GetDateStr()**

Classes vs. Graph Objects:

- **T…:** a class type; **TUNGraph**
- **P…:** type of a graph object; **PUNGraph**

Data Structures:

- **…V:** a vector, variable **TIntV InNIdV**
- **…VV:** a vector of vectors (i.e., a matrix), variable **FltVV**

  TFltVV … a matrix of floating point elements
- **…H**: a hash table, variable **NodeH**

  TIntStrH … a hash table with **TInt** keys, **TStr** values
- **…HH**: a hash of hashes, variable **NodeHH**

  TIntIntHH … a hash table with **TInt** key 1 and **TInt** key 2
- **…Pr:** a pair; type **TIntPr**

Snap.py Naming Conventions (2)

- **`Get...`**: an access method, **`GetDeg()`**
- **`Set...`**: a set method, **`SetXYLabel()`**
- **`...I`**: an iterator, **`NodeI`**
- **`Id`**: an identifier, **`GetUId()`**
- **`NId`**: a node identifier, **`GetNId()`**
- **`EId`**: an edge identifier, **`GetEId()`**
- **`Nbr`**: a neighbor, **`GetNbrNId()`**
- **`Deg`**: a node degree, **`GetOutDeg()`**
- **`Src`**: a source node, **`GetSrcNId()`**
- **`Dst`**: a destination node, **`GetDstNId()`**

Basic Types in Snap.py (and SNAP)

- **`TInt`**: Integer
- **`TFlt`**: Float
- **`TStr`**: String

- Used primarily for constructing composite types
- In general no need to deal with the basic types explicitly
  - Data types are automatically converted between C++ and Python
  - An illustration of explicit manipulation:

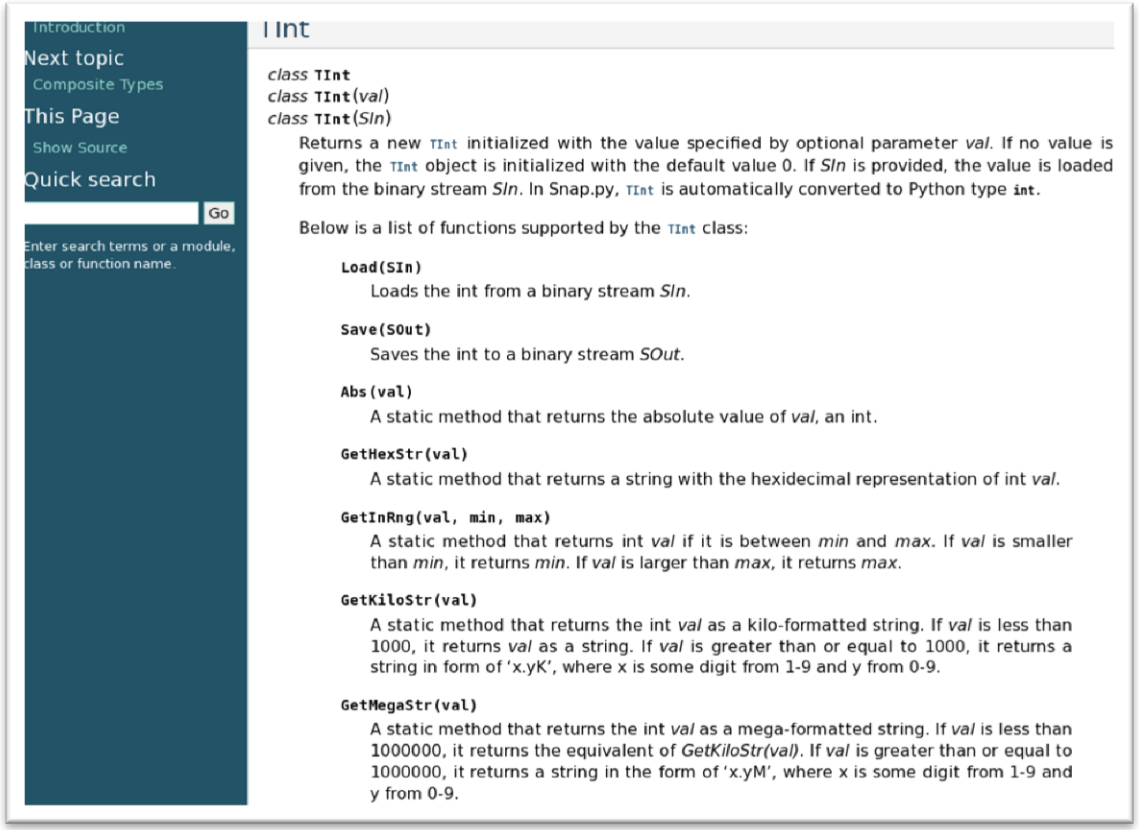
```
>>> i = snap.TInt(10)
>>> print i.Val
10
```

- **Note:** do not use an empty string “” in TStr parameters

Snap.py Reference Documentation

For more information check out Snap.py Reference Manual

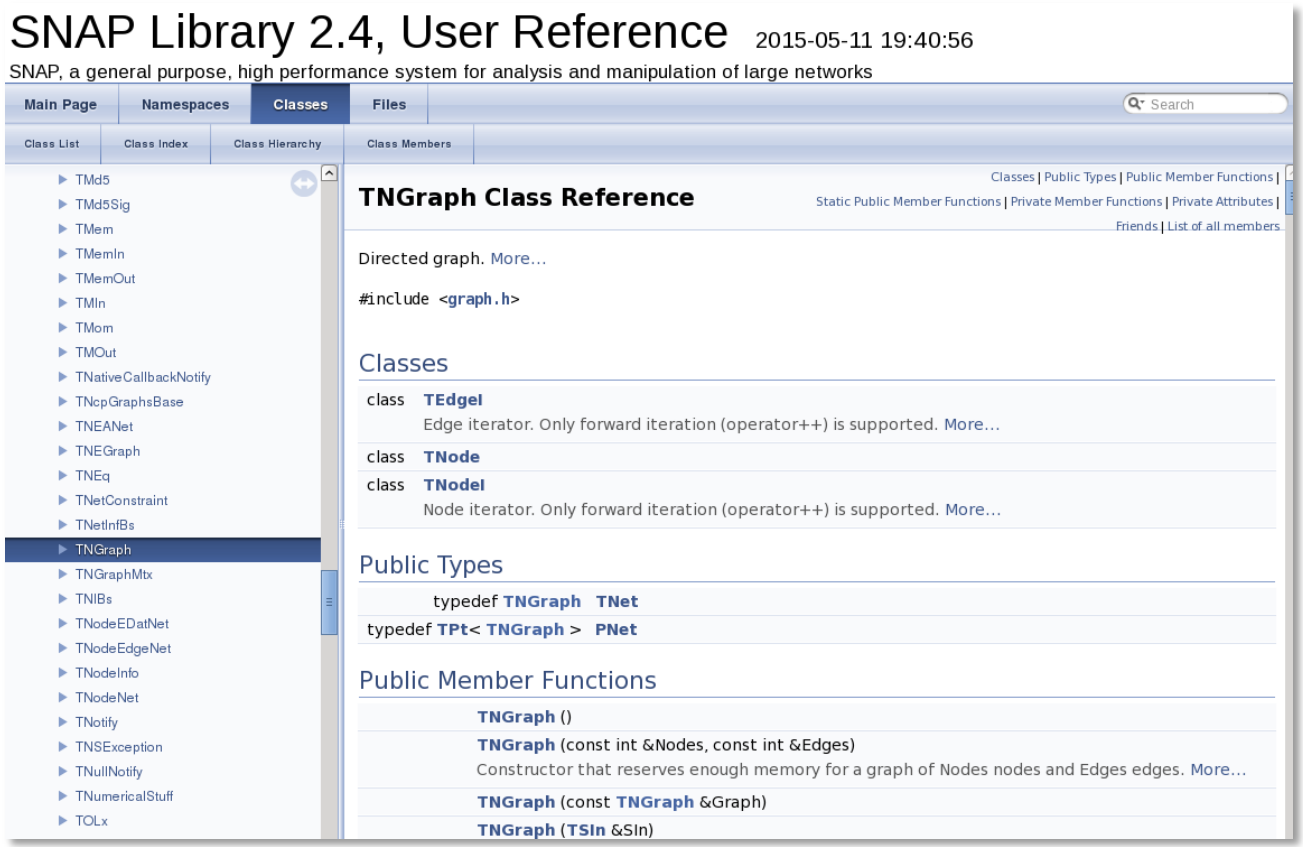
http://snap.stanford.edu/snappy/doc/reference/index-ref.html



SNAP C++ Documentation

SNAP User Reference Manual

http://snap.stanford.edu/snap/doc.html



Vector Types

- **Sequences of values of the same type**
  - New values can be added at the end
  - Existing values can be accessed or changed
- **Naming convention: `T<value_type>V`**
  - Examples: `TIntV, TFltV, TStrV`
- **Common operations:**
  - **`Add(<value>)`**: append a value at the end
  - **`Len()`**: vector size
  - **`[<index>]`**: get or set a value of an existing element
  - **`for i in V:`** iteration over the elements

Vector Example

```
v = snap.TIntV()

v.Add(1)
v.Add(2)
v.Add(3)
v.Add(4)
v.Add(5)

print v.Len()

print v[3]
v[3] = 2*v[2]
print v[3]

for item in v:
    print item
for i in range(0, v.Len()):
    print i, v[i]
```

Create an empty vector

Add elements

Print vector size

Get and set element value

Print vector elements

Hash Table Types

- **A set of (key, value) pairs**
  - Keys must be of the same types
  - Values must be of the same type
    - Value type can be different from the key type
  - New (key, value) pairs can be added
  - Existing values can be accessed or changed via a key
- **Naming: `T<key_type><value_type>H`**
  - **Examples:** `TIntStrH, TIntFltH, TStrIntH`
- **Common operations:**
  - **`[<key>]`**: add a new value or get or set an existing value
  - **`Len()`**: hash table size
  - **`for k in H`**: iteration over keys

Hash Table Example

```
h = snap.TIntStrH()

h[5] = "apple"
h[3] = "tomato"
h[9] = "orange"
h[6] = "banana"
h[1] = "apricot"

print h.Len()

print "h[3] =", h[3]

h[3] = "peach"
print "h[3] =", h[3]

for key in h:
    print key, h[key]
```

Create an empty table

Add elements

Print table size

Get element value

Set element value

Print table elements

Hash Tables: KeyID

- **`T<key_type><value_type>H`**
  - **`Key`**: item key, provided by the caller
  - **`Value`**: item value, provided by the caller
  - **`KeyId`**: integer, unique slot in the table, calculated by SNAP

KeyId	0	2	5
Key	100	89	95
Value	"David"	"Ann"	"Jason"

Pair Types

- **A pair of (value1, value2)**
  - Two values
    - type of value1 could be different from the value2 type
  - Existing values can be accessed
- **Naming: `T<type1><type2>Pr`**
  - **Examples:** `TIntStrPr, TIntFltPr, TStrIntPr`
- **Common operations:**
  - **`GetVal1`**: get value1
  - **`GetVal2`**: get value2

Pair Example

```
>>> p = snap.TIntStrPr(1,"one")
```

Create a pair

```
>>> print p.GetVal1()
1
>>> print p.GetVal2()
one
```

Print pair values

- **TIntStrPrV**: a vector of (integer, string) pairs
- **TIntPrV**: a vector of (integer, integer) pairs
- **TIntPrFltH**: a hash table with (integer, integer) pair keys and float values

Basic Graph and Network Classes

- **Graphs vs. Networks Classes:**
  - **`TUNGraph`**: undirected graph
  - **`TNGraph`**: directed graph
  - **`TNEANet`**: multigraph with attributes on nodes and edges
- Object types start with **P…**, since they use wrapper classes for garbage collection
  - **`PUNGraph, PNGraph, PNEANet`**
- Guideline
  - For class methods (functions) use **T**
  - For object instances (variables) use **P**

Graph Creation

```
G1 = snap.TNGraph.New()

G1.AddNode(1)
G1.AddNode(5)
G1.AddNode(12)

G1.AddEdge(1,5)
G1.AddEdge(5,1)
G1.AddEdge(5,12)

G2 = snap.TUNGraph.New()
N1 = snap.TNEANet.New()
```

Directed graph

Add nodes before adding edges

G1

Undirected graph, directed network

Graph Traversal

Node traversal

```
for NI in G1.Nodes():
    print "node id %d, out-degree %d, in-degree %d"
      % (NI.GetId(), NI.GetOutDeg(), NI.GetInDeg())
```

Edge traversal

```
for EI in G1.Edges():
    print "(%d, %d)" % (EI.GetSrcNId(), EI.GetDstNId())
```

Edge traversal by nodes

```
for NI in G1.Nodes():
    for DstNId in NI.GetOutEdges():
        print "(%d %d)" % (NI.GetId(), DstNId)
```

Graph Saving and Loading

Save text

```
snap.SaveEdgeList(G4, "test.txt", “List of edges")
```

Load text

```
G5 = snap.LoadEdgeList(snap.PNGraph,"test.txt",0,1)
```

Save binary

```
FOut = snap.TFOut("test.graph")
G2.Save(FOut)
FOut.Flush()
```

Load binary

```
FIn = snap.TFIn("test.graph")
G4 = snap.TNGraph.Load(FIn)
```

Text File Format

- **Example file: `wiki-Vote.txt`**
  - Download from http://snap.stanford.edu/data

```
# Directed graph: wiki-Vote.txt
# Nodes: 7115 Edges: 103689
# FromNodeId    ToNodeId
0       1
0       2
0       3
0       4
0       5
2       6
…
```

Load text

```
G5 = snap.LoadEdgeList(snap.PNGraph,"test.txt",0,1)
```

Plotting in Snap.py

- **Plotting graph properties**
  - Gnuplot: http://www.gnuplot.info
- **Visualizing graphs**
  - Graphviz: http://www.graphviz.org
- **Other options**
  - Matplotlib: http://www.matplotlib.org

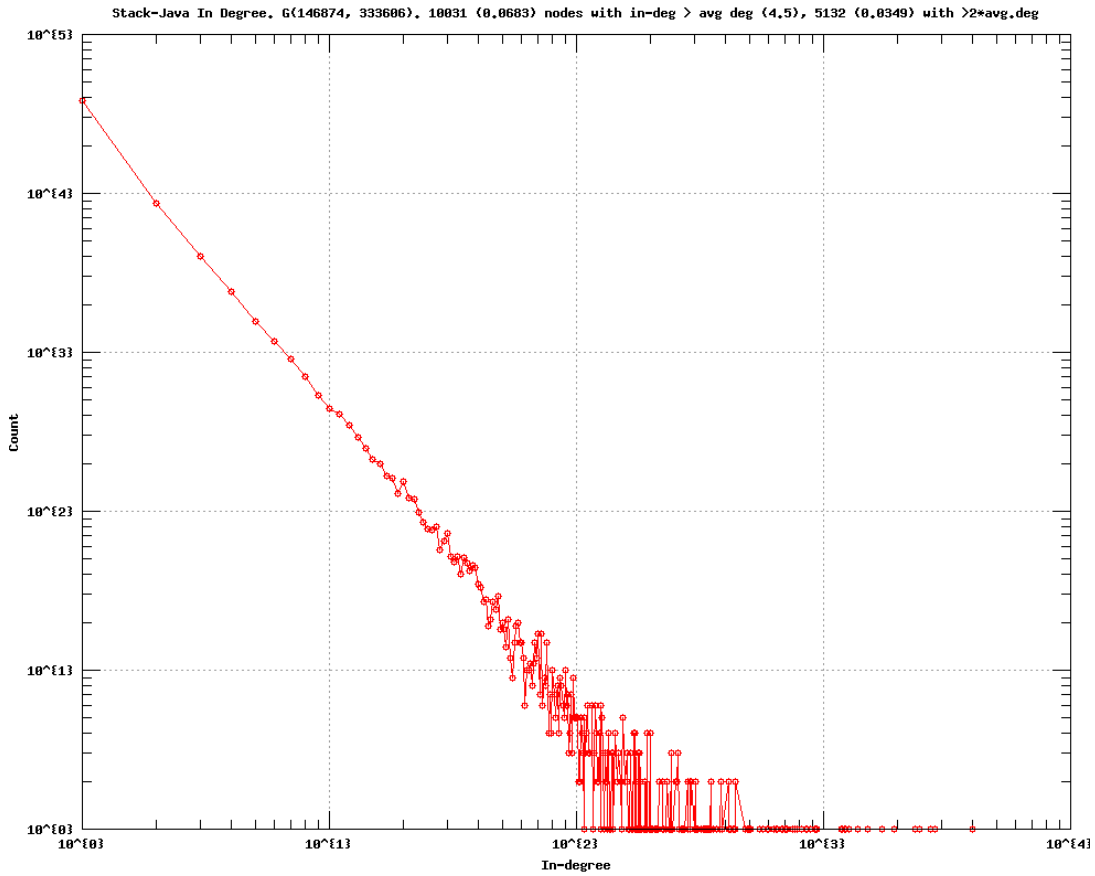
Plotting with Snap.py

- **Install Gnuplot:** http://www.gnuplot.info/

- Make sure that the directory containing wgnuplot.exe (for Windows) or gnuplot (for Linux, Mac OS X) is in your environmental variable **$PATH**

Plotting with Snap.py

```
import snap
G = snap.LoadEdgeList(snap.PNGraph, "qa.txt", 1, 5)
snap.PlotInDegDistr(G, "Stack-Java", "Stack-Java In Degree")
```



Graph of Java QA on StackOverflow: in-degree distribution

Snap.py + Gnuplot

- **Snap.py** generates three files:

  - **.png** or **.eps** is the plot
  - **.tab** file contains the data (tab separated file)
  - **.plt** file contains the plotting commands

Drawing Graphs

- **InstallGraphViz:** http://www.graphviz.org/

- Make sure that the directory containing GraphViz is in your environmental variable **$PATH**

Drawing Graphs with Snap.py

```
G1 = snap.TNGraph.New()

G1.AddNode(1)
G1.AddNode(5)
G1.AddNode(12)

G1.AddEdge(1,5)
G1.AddEdge(5,1)
G1.AddEdge(5,12)
```

Create graph

G1

```
NIdName = snap.TIntStrH()
NIdName[1] = "1"
NIdName[5] = "5"
NIdName[12] = "12"
```

Set node labels

Draw

```
snap.DrawGViz(G1, snap.gvlDot, "G1.png", "G1", NIdName)
```

Snap.py Resources

- **Prebuilt packages** available for Mac OS X, Windows, Linux
  http://snap.stanford.edu/snappy/index.html
- **Snap.py documentation**:
  http://snap.stanford.edu/snappy/doc/index.html
  - Quick Introduction, Tutorial, Reference Manual
- **SNAP user mailing list**
  http://groups.google.com/group/snap-discuss
- **Developer resources**
  - Software available as open source under BSD license
  - GitHub repository
    https://github.com/snap-stanford/snap-python