Tutorial: Large Scale Network Analytics with SNAP

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

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SNAP C++

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SNAP C++ Installation

- **Download the latest version of SNAP C++**

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

Download SNAP

Current SNAP Release

Download the current SNAP distribution package:

SNAP 2.2 (Mar 12, 2014)

A public development SNAP repository is available at GitHub:

snap-stanford/snap

SNAP C++ Repository

- **Graph and network library:** directory **`snap-core`**
  - Graph and network generation, manipulation, algorithms
- **Data structures:** directory **`glib-core`**
  - STL-like library
  - Contains basic data structures, like vectors, hash tables and strings
  - Provides serialization for loading and saving
- **Tutorials:** directory **`tutorials`**
  - Short programs that demonstrate basic functionality
- **Example applications:** directory **`examples`**
  - Complete sample applications
- **Advanced capabilities:** directories **`snap-adv`**, **`snap-exp`**

SNAP Quick Start Guide

- **Download and unzip** **Snap package**
  - http://snap.stanford.edu/snap/download.html
- **Compile programs** in subfolder **`examples`**
  - Windows Visual Studio
    - `Project file` **`SnapExamples*.sln`**
  - Mac OS x with Xcode
    - `Project file` **`snap-examples*.xcodeproj`**
  - Command line on Linux, Mac OS X, Cygwin
    - **`Makefile`**
- For **your own project**, copy **`examples/testgraph`** and modify it

Installation on Windows

- Install Visual Studio or Visual Studio Express
  - http://www.visualstudio.com/
- **Download and Unzip Snap package**
  - http://snap.stanford.edu/snap/download.html
- Go to subfolder **`examples`**
- Open project **`SnapExamples*.sln`**
  - Visual Studio 2008 and 2010 projects are available

Visual Studio: Creating New Project

- **1)** Open Visual Studio and create a project
  - Or start with **`examples/testgraph`** and modify it
- **2)** Include **`Snap.h`** in your main program
  `#include "Snap.h"`
- **3)** Include the path to directories "**`snap-core`**", "**`glib-core`**" and "`snap-adv`" in your project
  - Properties → *Configuration Properties* → *VC++ Directories* → *Include Directories*
- **4)** Character set must be configured to Multi-Byte:
  - Properties → *Configuration Properties* → *General* → *Projects Defaults* → *Character Set* → *Select "Use Multi-Byte Character Set"*

Installation on Mac OS X with Xcode

- Install Xcode
  - https://developer.apple.com/xcode/
- **Download and Unzip Snap package**
  - http://snap.stanford.edu/snap/download.html
- Go to subfolder **`examples`**
- Open project **`snap-examples*.xcodeproj`**
- Build the project and execute examples

Xcode – Creating New Project

- **Open Xcode and create a project**
  - Or start with **`examples/testgraph`** and modify it

- Include "**`Snap.h`**" in your main program

```
#include "Snap.h"
```

Command Line Installation on Linux, Mac OS X, Windows with Cygwin

- For command line-based systems (e.g., Linux, OsX, Cygwin), use the **`Makefile`** in the example folder

- Makefiles are available in all folders in "**`examples`**", e.g., **`examples/kronfit/Makefile`**

Basic Graph Types

- **`TUNGraph`**: undirected graph
- **`TNGraph`**: directed graph
- **`TNEANet`**: directed multi-graph with attributes

Graph Creation

- **Create a graph:**

```
PNGraph Graph = TNGraph::New();
Graph->AddNode(1);
Graph->AddNode(5);
Graph->AddEdge(1,5);
```

- **Use smart-pointers**
  - `typedef TPt<TNGraph> PNGraph`
  - Memory management
    - Objects are automatically released when not needed

- Add nodes (`G->AddNode(i)`) before adding edges (`G->AddEdge(i,j)`)

Graph Traversal

- **Traverse the nodes**

```
for (TNGraph::TNodeI NI = Graph->BegNI(); NI < Graph->EndNI(); NI++)
  printf("%d %d %d\n",  NI.GetId(), NI.GetOutDeg(), NI.GetInDeg());
```

- **Traverse the edges, globally**

```
for (TNGraph::TEdgeI EI = Graph->BegEI(); EI < Graph->EndEI(); EI++)
  printf("edge (%d, %d)\n", EI.GetSrcNId(), EI.GetDstNId());
```

- **Traverse the edges, per node**

```
for (TNGraph::TNodeI NI = Graph->BegNI(); NI < Graph->EndNI(); NI++)
  for (int e = 0; e < NI.GetOutDeg(); e++)
    printf("edge (%d %d)\n", NI.GetId(), NI.GetOutNId(e));
```

Node and Edge Iterators

- **Get a node iterator from node id:**

```
TNGraph::TNodeI NI = Graph->GetNI(NId);
```

- **Get an edge iterator from node ids:**

```
TNGraph::TEdgeI EI = Graph->GetEI(SrcNId,DstNId);
```

Loading/Saving of Graphs

- **Loading a graph in the edge list, text format**

```
PUNGraph G2 =
TSnap::LoadEdgeList<PUNGraph>("as20graph.txt",0,1);
```

  - 0 (1) is the column id for source (target) node

- **Saving a graph in the edge list, text format**

```
TSnap::SaveEdgeList<PUNGraph>(G2, "as20graph.txt", "");
```

- **Loading/Saving in a binary format – faster**

```
{ TFIn FIn("test.graph"); PNGraph G2 =
TNGraph::Load(FIn); }
{ TFOut FOut("test.graph"); G2->Save(FOut); }
```

  - **Note the parenthesis {}!**

Edge List, Text File Format

- **Example file:**
  `as20graph.txt` in subfolder **`examples`**

```
# Directed Node Graph
# Autonomous systems …
# Nodes: 6474    Edges: 26467
# SrcNId   DstNId
1   3
1   6
1   32
1   48
1   63
1   70
…
```

Graph Operations (Examples 1)

- **Get degree distribution (degree, count)**

```
TSnap::GetOutDegCnt(G, CntV);
```

- **Get distribution of connected components (component size, count)**

```
TSnap::GetWccSzCnt(G, CntV);
```

  - CntV is a vector of pairs of integers:

```
TVec < TPair<TInt, TInt> > CntV;
```

Generating Graphs

- **Generate graphs with specific properties**
- Use functions **TSnap::Gen…**

`TSnap::GenRndGnm()`: G_{nm} Erdős–Rényi graph

`TSnap::GenForestFire`, Forest Fire Model

`TSnap::GenPrefAttach`, Preferential Attachment

- **Example:**
  - Create a directed random graph on 100 nodes and 1k edges

```
PNGraph Graph =
TSnap::GenRndGnm<PNGraph>(100, 1000);
```

Graph Operations (Examples 2)

- **Generate a network using Forest Fire model**

```
PNGraph G = TSnap::GenForestFire(1000, 0.35, 0.35);
```

- **Convert to undirected graph TUNGraph**

```
PUNGraph UG = TSnap::ConvertGraph<PUNGraph, PNGraph> (G);
```

- **Get largest weakly connected component of G**

```
PNGraph WccG = TSnap::GetMxWcc(G);
```

- **Get a subgraph induced on nodes {0,1,2,3,4}**

```
PNGraph SubG = TSnap::GetSubGraph(G,
TIntV::GetV(0,1,2,3,4));
```

SNAP Network Types

- **`TNodeNet<TNodeData>`**: directed graph with TNodeData object for each node
- **`TNodeEDatNet<TNodeData, TEdgeData>`**: directed graph with TNodeData on each node and TEdgeData on each edge
- **`TNodeEdgeNet<TNodeData, TEdgeData>`**: directed multi-edge graph with TNodeData on each node and TEdgeData on each edge

Example Applications

- In SNAP directory "`examples`"
- **`TestGraph`**: Demonstrates basic functionality of the library, modify this example for your own project
- **`ForestFire`**: ForestFire graph generative model
- **`Cliques`**: Clique Percolation Method for detecting overlapping communities
- **`Cascades`**: Simulate susceptible-infected model on a network
- **`AGMFit, BigClam, CODA, Cesna`**: Community detection methods

SNAP Data Structures and Types

- In directory **`glib-core`**
- **Key files:**
  - **`dt.h`**: Data Types (`TInt, TFlt`)
  - **`ds.h`**: Data Structures (`TVec`)
- **Numbers:**
  - Integers: `TInt`
  - Real numbers: `TFlt`
  - Example:

```
TInt A = 5;
printf("%d\n", A.Val);
```

Basic SNAP Types

- **String: TStr**
  - **Examples:**

```
TStr A = "abc";
TStr B = "ccc";
printf("string %s\n", A.CStr());   // -- abc
printf("length %d\n", A.Len());    // -- 3
printf("A[0] %c\n", A[0]);         // -- a
printf("A==B %d\n", A == B);       // -- 0
```

SNAP Data Structures

- **Pair**
  - **TPair <Type1, Type2>**
    (Types can also be complex types like TVec, TPair…)

```
TPair<TInt, TFlt> A;
A.Val1 = 3;
A.Val2 = 3.14;
```

  - **Predefined types in ds.h**

```
typedef TPair<TInt, TInt> TIntPr;
typedef TPair<TInt, TIntPr> TIntIntPrPr;
```

- **Triple**
  - TTriple <Type1, Type2, Type3>

SNAP Vectors

- **TVec<Type>**
  - Example:

```
TVec<TInt> A;
A.Add(10);
A.Add(20);
A.Add(30);
printf("length %d\n", A.Len());    // -- 3
printf("A[0] %d\n", A[0].Val);     // -- 10
```

  - **"Type" can be a complex type**

```
TVec< TVec< TVec<TFlt> > >
```

  - **Predefined types in ds.h**

```
typedef TVec<TInt> TIntV;
Typedef TVec<TFlt> TFltV;
```

SNAP Hash Tables

- `THash <key, value>`
  - **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"

SNAP Hash Tables

- **Example:**

```
THash<TInt, TStr> A;
A.AddDat(100) = “David”;
A.AddDat(89) = “Ann”;
A.AddDat(95) = “Jason”;
printf(“%s\n”, A.GetDat(89).CStr()); // -- Ann, Key to Value
printf(“%d\n”, A.GetKeyId(95));      // -- 5, Key to KeyId
printf(“%d\n”, A.GetKey(5).Val);     // -- 95, KeyId to Key
printf(“%s\n”, A[5].CStr());         // -- Jason, KeyId to Value
```

- Predefined types in hash.h

```
typedef THash<TInt, TInt> TIntIntH;
Typedef THash<TInt, TFlt> TIntFltH;
```

Saving and Loading Objects

- **Binary files**
  - Fast save/load
  - Memory efficient
- **Save():**

```
TIntStrH A;
{ TFOut fout("a.bin");
A.Save(fout); }
```

- **Load():**

```
{ TFIn fin("a.bin"); A.Load(fin); }
```

Generating Distributions

- **TRnd class**
  - Generate random numbers according to various probability distributions
- **Example:**

```
TRnd A;
//sample from an exponential distribution
for (int i=0; i<10; ++i){
  printf("%f\n",A.GetExpDev(1));
}
```

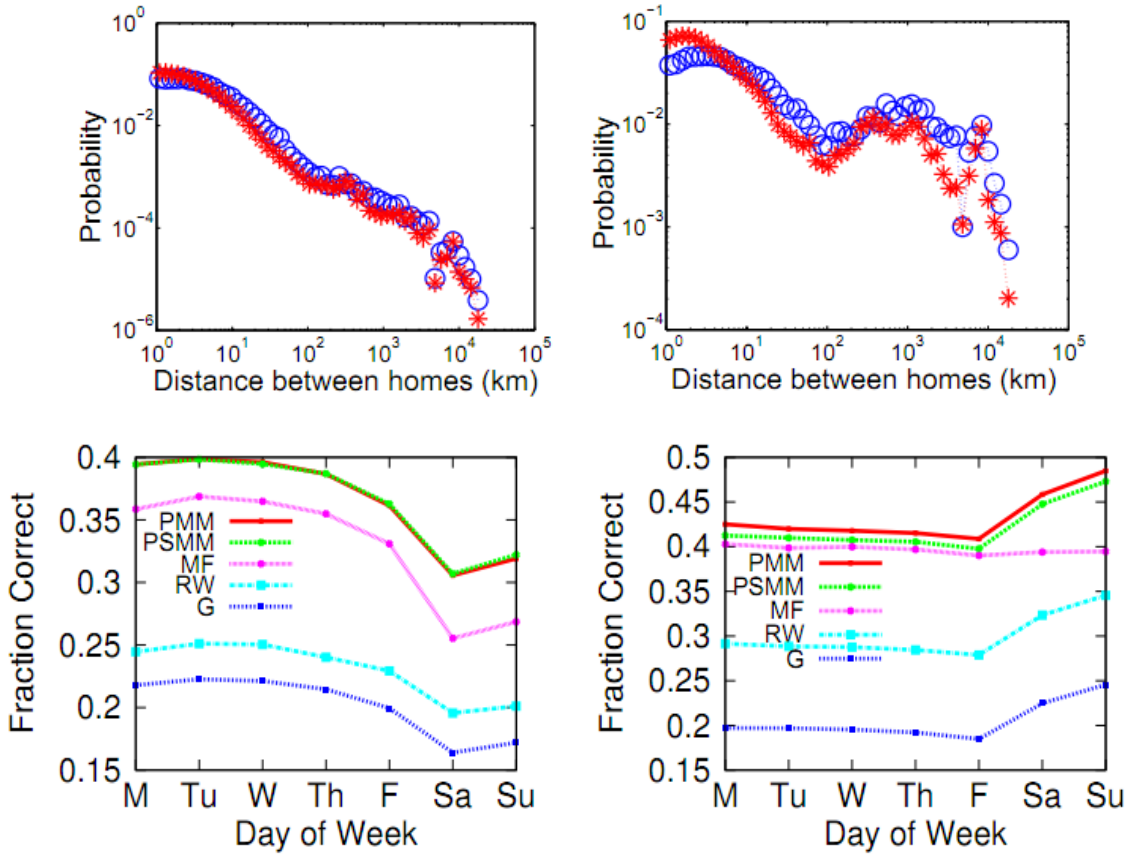
Calculating Statistics

- **File `glib-core/xmath.h`**
  - Useful for calculating moments, correlation coefficients, t-test, …
- **Example of computing moments (`TMom`):**

```
TMom Mom;
Mom.Add(5);  Mom.Add(6);  Mom.Add(8);
Mom.Def();
printf("Avg: %f\n", Mom.GetMean());
printf("Min: %f\n", Mom.GetMn());
printf("Max: %f\n", Mom.GetMx());
```

Making Plots

- **Making a plot in SNAP**



Making Plots in SNAP

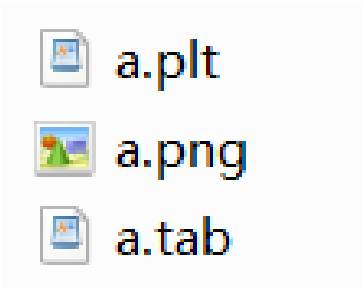
- **1) Install Gnuplot** http://www.gnuplot.info/
  - Make sure that the directory containing wgnuplot.exe (for Windows) or gnuplot (for Linux, Mac OS X) is in your environmental variable $PATH.

- **2)** Use **`TGnuPlot`** (`glib-core/gnuplot.h`):

```
TVec<TPair<TFlt, TFlt > > XY1, XY2; …
TGnuPlot Gp(“file name”, “title name");
Gp.AddPlot(XY1, gpwLinesPoints, “curve1");
Gp.AddPlot(XY2, gpwPoints, “curve2");
Gp.SetXYLabel(“x-axis name", “y-axis name”);
Gp.SavePng(); //or Gp.SaveEps();
```

Gnuplot in SNAP

- **After executing, three files are generated**



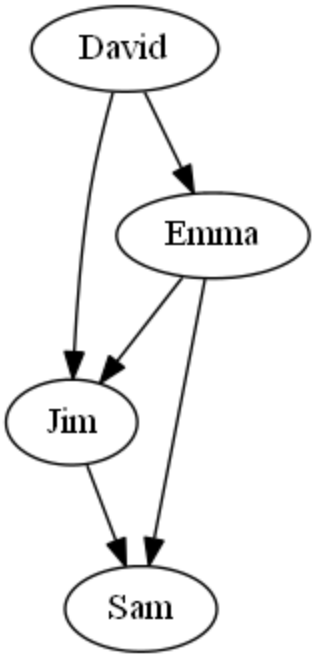
  - **.plt** file includes plotting commands for gnuplot
  - **.tab** file contains the tab separated data
  - **.png** or **.eps** is the plot

Drawing SNAP Graphs

- Use **`TGraphViz`**
  - Need to install GraphViz software first http://www.graphviz.org/
- Add GraphViz path to environment variable

Drawing SNAP Graphs

```
PNGraph G = TNGraph::New();
G->AddNode(1); G->AddNode(2);
G->AddNode(3); G->AddNode(4);
G->AddEdge(1,2); G->AddEdge(2,3);
G->AddEdge(1,3); G->AddEdge(2,4);
G->AddEdge(3,4);
TIntStrH Name;
Name.AddDat(1)="David";
Name.AddDat(2)="Emma";
Name.AddDat(3)="Jim";
Name.AddDat(4)="Sam";
TGraphViz::Plot<PNGraph>(G, gvlDot,
      "gviz_plot.png", "", Name);
```



SNAP C++ Resources

- **Source code** available for Mac OS X, Windows, Linux
  http://snap.stanford.edu/snap/download.html
- **SNAP documentation**
  http://snap.stanford.edu/snap/doc.html
  - Quick Introduction, User Reference Manual
  - Source code, see **tutorials**
- **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
  - SNAP C++ Programming Guide