NetdiffuseR

Brief introduction and new capabilities

Aníbal Olivera, George Vega Yon, and Thomas Valente

1. Introduction
    a. Network diffusion of Innovations
    b. netdiffuseR

2. Simulation of diffusion networks
    a. rdiffnet

4. Analyzing rdiffnet
    a. Single-behavior inputs
    b. Multi-behavior inputs

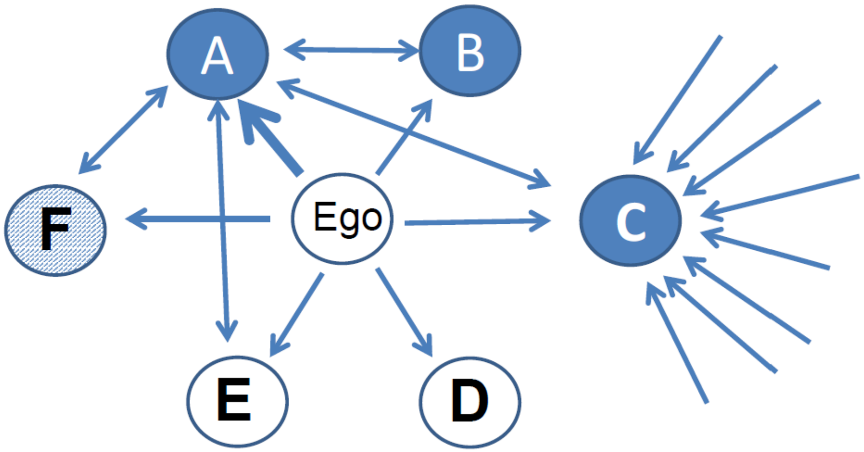
5. Some examples

Introduction

Network diffusion of Innovations

Diffusion networks

- Considerable research has been conducted to show that certain behaviors are **contagious** and spread through person-to-person contact [1].



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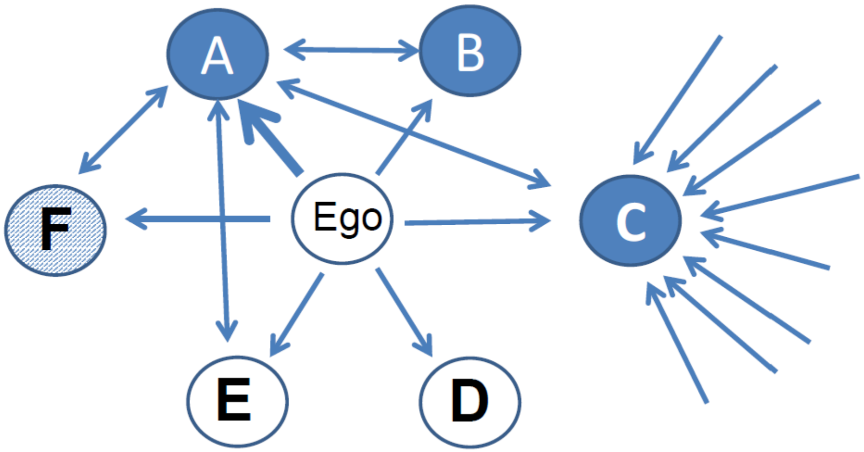

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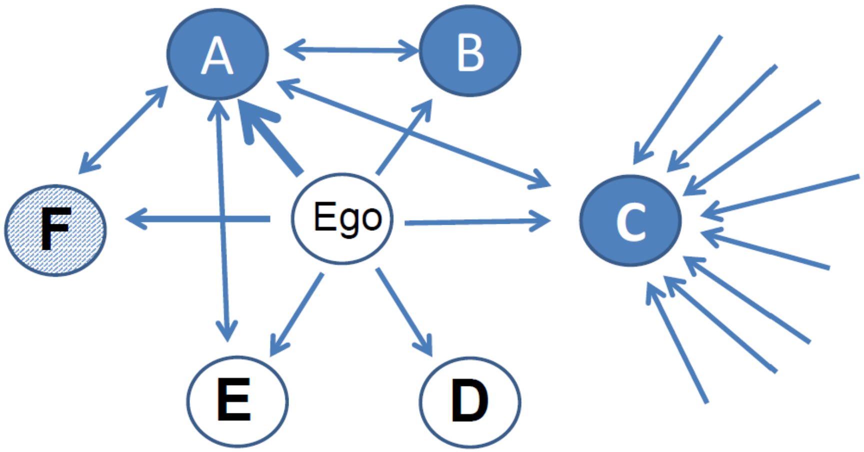

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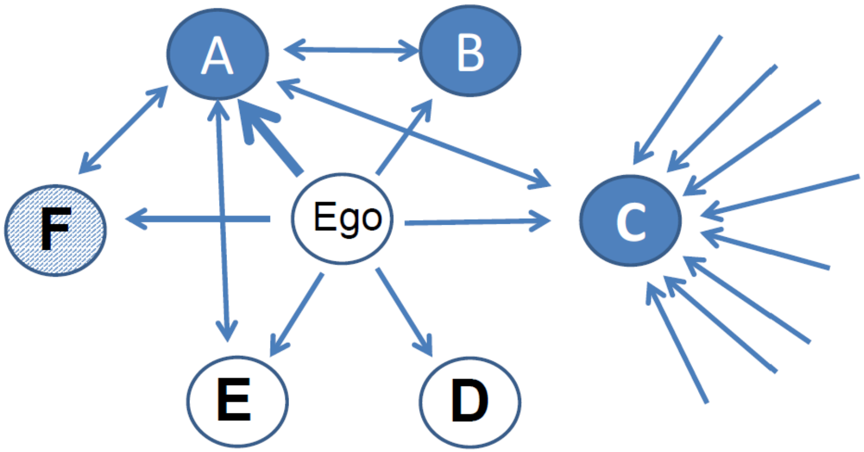

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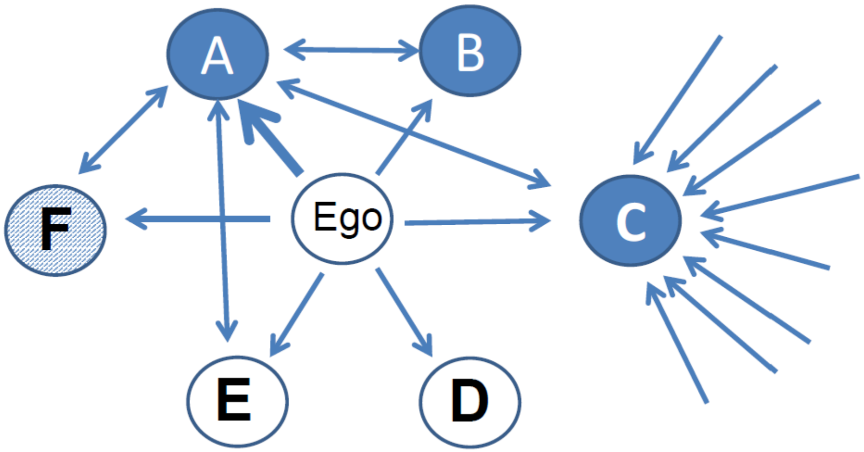

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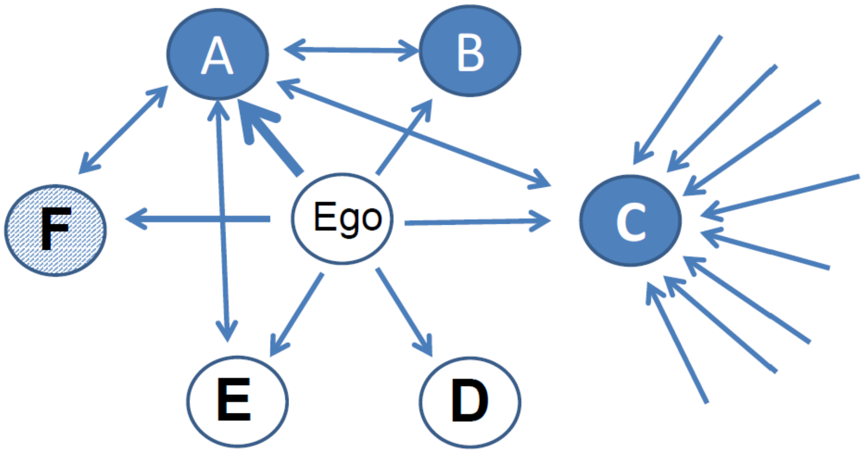
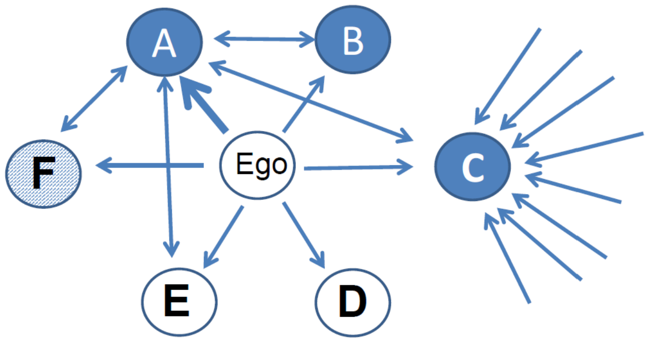
- Political behavior [6,7],
- Technological innovations [8,9,10],
- How urban rumors spread [11],
- etc…



Diffusion networks

- **Contagion:** the transmission of a disease by direct or indirect contact and also an **influence** that spreads rapidly.



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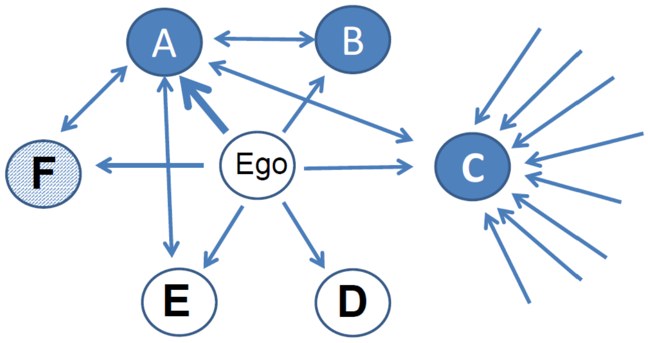

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- Marketing campaign,
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- Etc..

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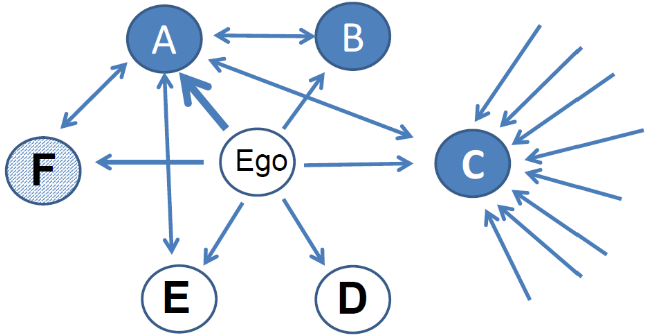

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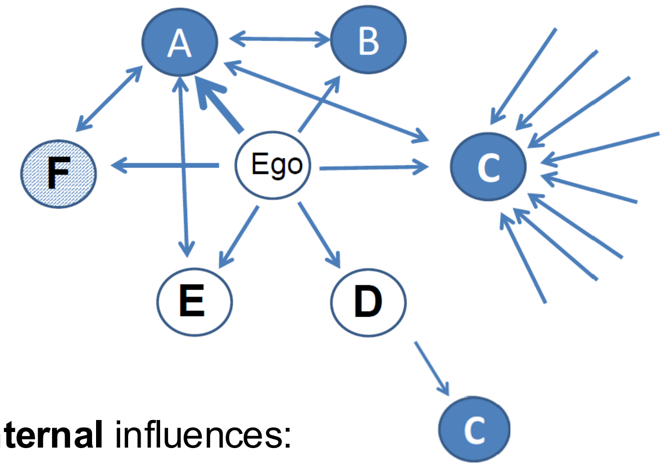

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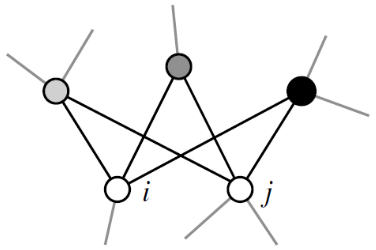

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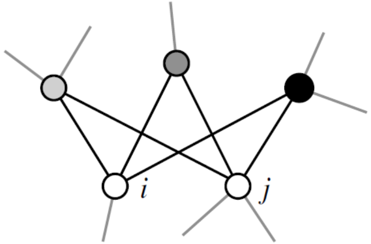

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Types of **internal** influences:

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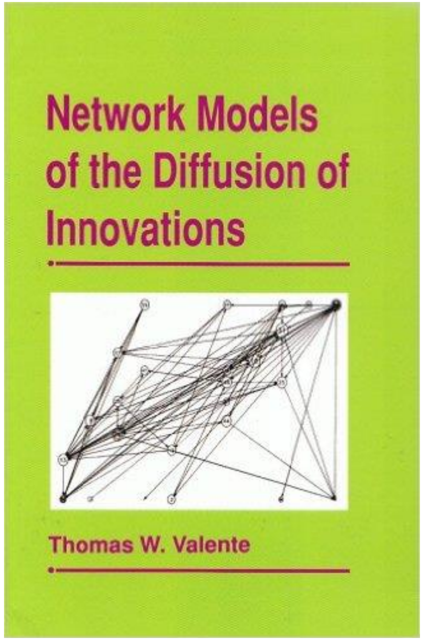
- Indirect Exposure
- Structural Equivalence
- Exposure weighted by tie strength
- Etc..

Diffusion networks



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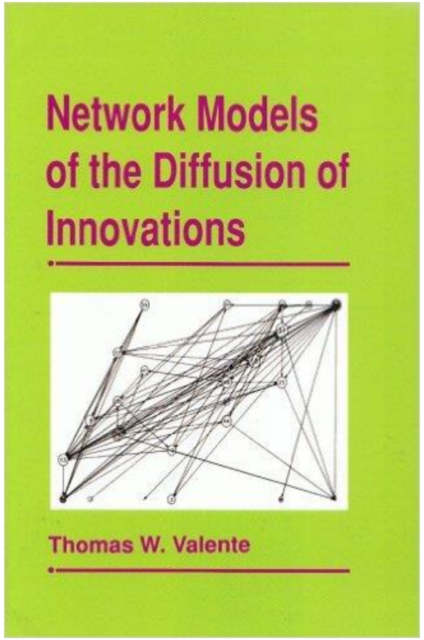

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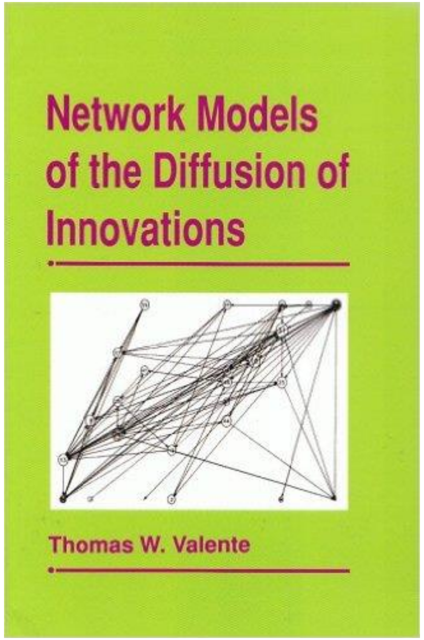

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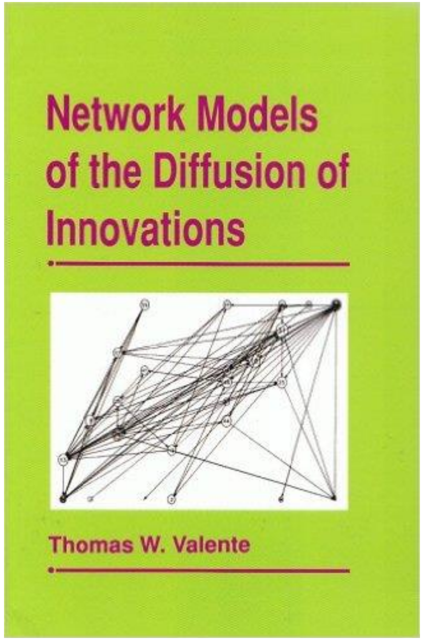

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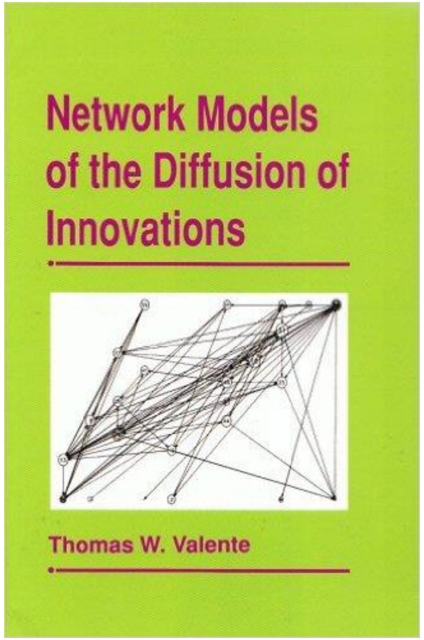

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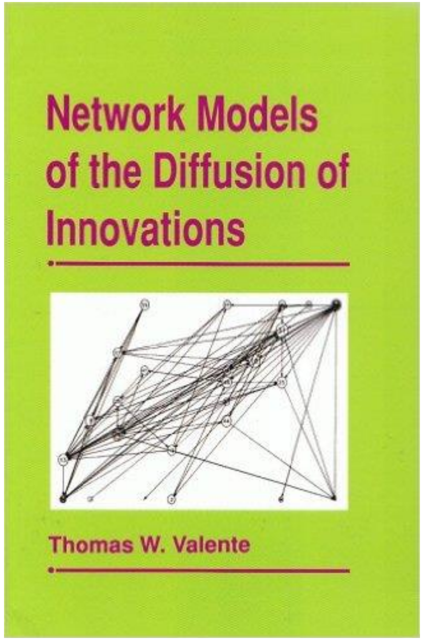

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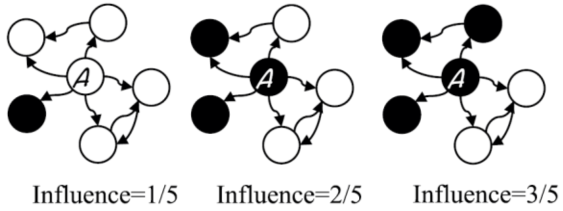
  - diffusion rates (bass model),
  - etc..

Thresholds

- One of the cannonical concepts is the threshold of adoption τ_i :

"Required proportion or number of neighbors that leads you to adopt a particular behavior or innovation"



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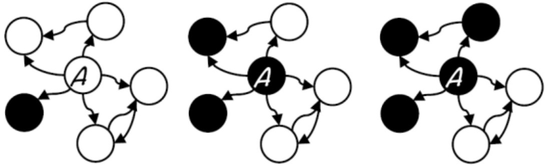

Influence=1/5 Influence=2/5 Influence=3/5

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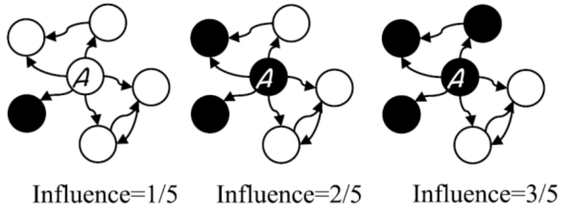

- To calculate the exposition:

$$E_i \equiv \frac{\sum_{j \neq i} \mathbf{X}_{ij} a_j}{\sum_{j \neq i} \mathbf{X}_{ij}}$$

- So we can check if the node *i* adopts or not:

$$a_i = \begin{cases} 1 & \text{if } \tau_i \leq E_i \\ 0 & \text{Otherwise} \end{cases}$$

Adoption and disadoption

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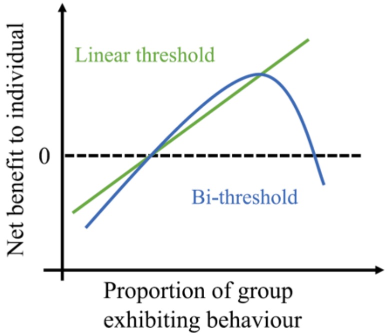

$$P(adopt_i) = \mathrm{logit}^{-1}(\beta_{adopt} exposure_i + \beta^{adopt} x)$$

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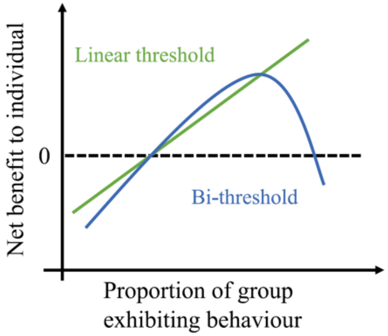

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- So, we need a way to simulate the diffusion of **multiple behaviors**.

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- A lot of features to make it easy to work with several kinds of networks, so has **high compatibility** with others net packages.

Simulation of diffusion networks

netdiffuseR

Let's focus on **simulating** data

→ rdiffnet()

`rdiffnet` *Random diffnet network*

Description

Simulates a diffusion network by creating a random dynamic network and adoption threshold levels.

Usage

```
rdiffnet_multiple(R, statistic, ..., ncpus = 1L, cl = NULL)

rdiffnet(
  n,
  t,
  seed.nodes = "random",
  seed.p.adopt = 0.05,
  seed.graph = "scale-free",
  rgraph.args = list(),
  rewire = TRUE,
  rewire.args = list(),
  threshold.dist = runif(n),
  exposure.args = list(),
  name = "A diffusion network",
  behavior = "Random contagion",
  stop.no.diff = TRUE
)
```

netdiffuseR

Let's focus on **simulating** data

→ rdiffnet()

- The simulation algorithm is as follows:
  - If required, a baseline graph is created,
  - Set of initial adopters and threshold distribution are established,
  - The set of t networks is created (if required), and
  - Simulation starts at t=2, assigning adopters based on exposures and thresholds:
    - For each *i* ∈ N, if its exposure at t−1 is greater than its threshold, then adopts, otherwise continue without change.
    - next *i*

netdiffuseR

For example:

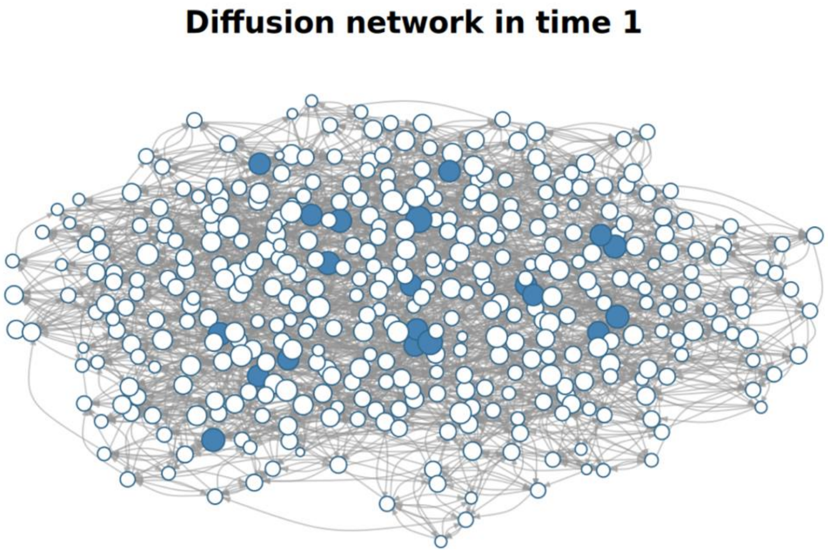
```r
set.seed(12315)
x <- rdiffnet(
  400, t = 6, rgraph.args = list(k=6, p=.3),
  seed.graph = "small-world",
  seed.nodes = "central", rewire = FALSE, threshold.dist = 1/4
  )
```

- 400 nodes
- 6 time steps
- ‘Small-world’ network
- (k=6) Each node is initially connected to 6 neighbors
- (p=.3) probability of rewiring
- Seed nodes selected as those with higher degree centrality
- Static network
- Threshold uniform to all nodes

netdiffuseR

For example:

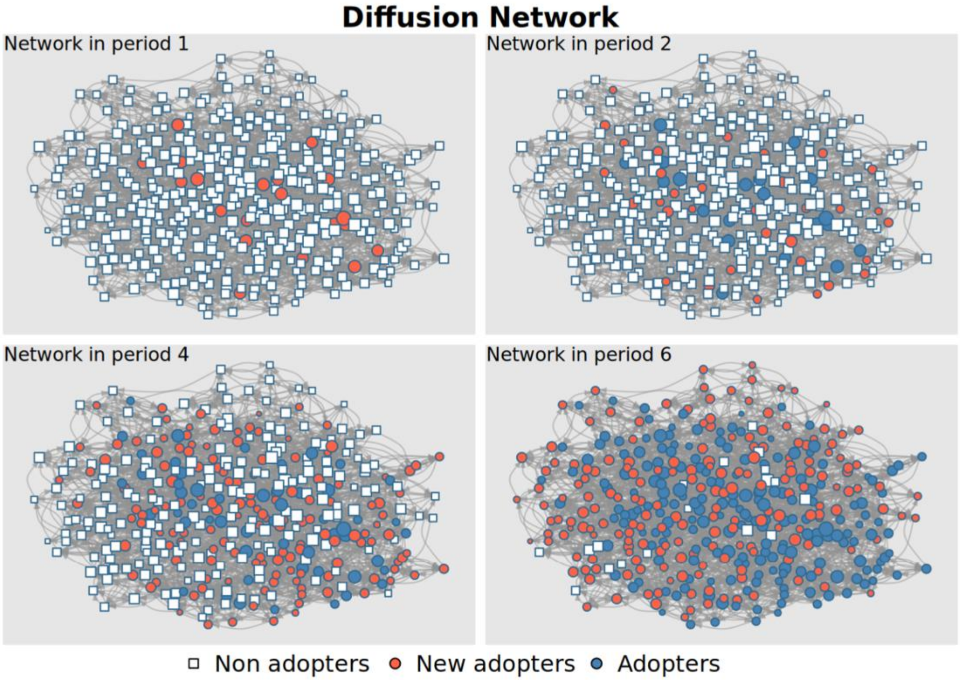
```
plot(x)
```



netdiffuseR

For example:

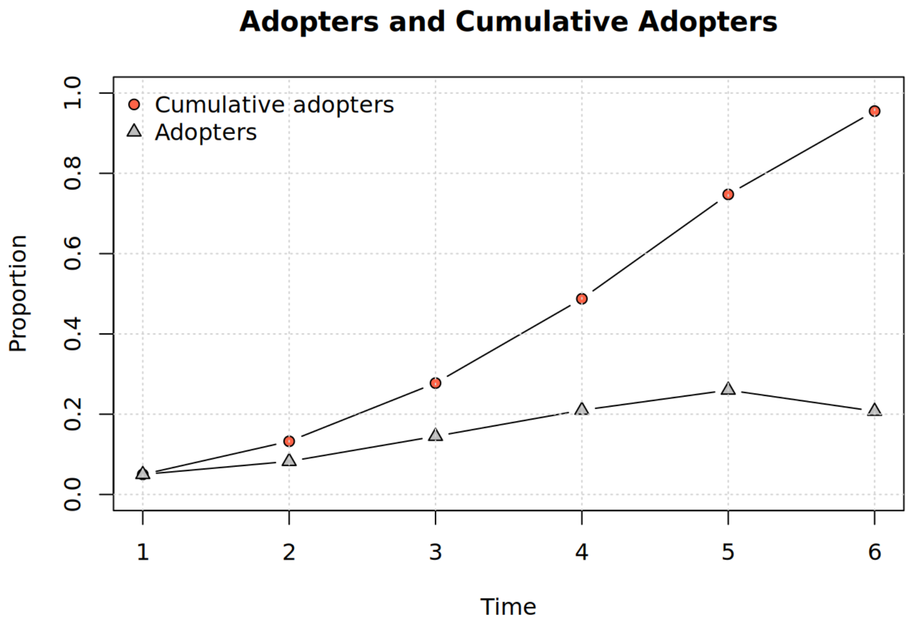
```
plot_diffnet(x)
```



netdiffuseR

For example:

```
plot_adopters(x)
```



Analyzing rdiffnet

Single-behavior rdiffnet

rdiffnet(graph, seed.p.nodes, seed.nodes, behavior, threshold.dist)

Step 0.0: seeting *n* and *t* if not provided

- this depends on graph

Step 1.0: seeting seed nodes

- this depends on seed.p.nodes and seed.nodes

Step 2.0: seeting threshold for each node

⮡ `rdiffnet_make_threshold( threshold.dist, n )`

Step 3.0: running the simulation

⮡ `exposure( graph, exposure.args = list(...) )`

⮡ allow us to compute time of adoption (toa)

Step 4.0: creating diffnet object

⮡ `new_diffnet( graph, ..., toa, ... )`

Single-behavior inputs

		single
seed.p.adopt	numeric	0.1 c(0.1)
	character	✗
	list	✗
seed.nodes	numeric	c(2,4,6)
	character	“random” c(“random”)
	list	✗
behavior	numeric	✗
	character	“tabacco” c(“tabacco”)
	list	✗
threshold	numeric	0.33 rep(0.33, 100)
	function	function() runif(1)
	matrix	✗
	list	✗

Multiple-behavior rdiffnet

rdiffnet(graph, seed.p.nodes, seed.nodes, behavior, threshold.dist)

Step 0.0: seeting *n* and *t* if not provided

- this depends on graph

Step 1.0: validate the arguments

```
rdiffnet_validate_args(seed.p.adopt, seed.nodes, behavior)
```

- this allow us to seeting seed nodes

Step 2.0: seeting threshold for each node

```
rdiffnet_make_threshold( threshold.dist, n, num_of_behaviors)
```

Step 3.0: running the simulation

```
exposure( graph, exposure.args = list(...) )
```

```
disadopt( expo, cumadopt, t)
```

- to compute time of adoption (toa) for each behavior

Step 4.0: creating diffnet object

```
new_diffnet( graph, ..., toa, ... )
```

Multiple-behavior rdiffnet

Step 3.0: running the simulation

exposure(graph, exposure.args = list(...))

disadopt(expo, cumadopt, t)

- to compute time of adoption (toa) for each behavior

Step 4.0: creating diffnet object

new_diffnet(graph, ..., toa, ...)

Step 5.0: splitting behaviors (optional)

split_behaviors(rdiffnet_multiple_obj)

Multiple-behavior inputs

		single		multiple
seed.p.adopt	numeric	0.1 c(0.1)	numeric	
	character		character	
	list		list	list(0.1, 0.05)
seed.nodes	numeric	c(2,4,6)	numeric	c(2,4,6)
	character	“random” c(“random”)	character	“random” c(“random”) c(“random”, “central”)
	list		list	list(“random”, “central”) list(c(1,3,5), c(2,4,6))

Multiple-behavior inputs

		single	multiple
behavior	numeric		
	character	"tabacco" c("tabacco")	"tabacco" c("tabacco") c("tabacco", "alcohol")
	list		list("tabacco", "alcohol")
threshold	numeric	0.33 rep(0.33, 100)	0.33 rep(0.33, 100)
	function	function() runif(1)	function() runif(1)
	matrix		matrix(runif(100), n_nodes, n_behavior)
	list		list(0.33, 0.66) list(runif(100), runif(100)) list(function() runif(1), function() runif(1))

Some examples

To Rstudio

Thank you!

Reference

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