Epidemic algorithms mimic the transmission of infectious diseases and are often used in distributed

systems to accomplish tasks such as:

• Disseminating information (e.g., topology information).

• Compute aggregates (e.g., arrange the nodes in a gossip overlay into a list sorted by some attributes

in logarithmic time).

• Manage data replication in a distributed system [149,180,181].

The game of life is a very popular epidemic algorithm invented by John Conway [46].

Several classes of epidemic algorithm exist; the concepts used to classify these algorithms as susceptible,

infective, or recovered refer to the state of the individual in the population subject to infectious

disease and, by extension, to the recipient of information in a distributed system:

• Susceptible. The individual is healthy but can get infected; the system does not know the specific

information but can get it.

• Infective. The individual is infected and able to infect others; the system knows the specific information

and uses the rules to disseminate it.

• Recovered. The individual is infected but does not infect others; the system knows the specific

information and does not disseminate it.

7.12.1 Susceptible-Infective (SI)

The SI algorithms apply when the entire population is susceptible to be infected. Once an individual

becomes infected, it remains in that state until the entire population is infected. If I (t) is the number of

individuals infected, S(t) is the number of individuals susceptible to be infected, and R(t) the number

of those infected and then recovered at time t, and if all individuals have an equal probability β of

contracting the disease, then

I (0)

2[1 − I (0)]   I (t)

I (0)

1 − I (0)

e−βt (7.36)

and

1

2

1

S(0) − 1

e−βt   S(t)

1

S(0) − 1

e−βt (7.37)

when we assume that I (t) and S(t) are continuous variables rather than natural numbers.

SIR algorithms are based on the model developed by Kermack and McKendrik in 1927 [189]. The

model assumes the following transition from one state to another: S  → I  → R. It also assumes that

1/γ is the average infectious period and that the size of the population is fixed:

S(t) + I (t) + R(t) = N. (7.38)

The dynamics of the model are captured by the following equations:

dS(t)

dt

= −βS(t)I (t),

d I(t)

dt

= βS(t)I (t) − γ I (t), and

dR(t)

dt

= γ I (t). (7.39)

SIS algorithms [57] are particular cases of SIR models in which individuals recover from the disease

without immunity. If p = R(r)/I (r ), then the number of newly infected grows until (1 − p)/2 are

infected and then decreases exponentially to (1 − p) according to the expression

I (r ) = 1 − p

1 +

(1−p)N

I (0)

− 1

    N.

Recall that the m-th moment of the power-law distribution of a discrete random variable X,

PX (x = k) = k−γ , is

E

Xm

=

∞

k=1

km PX (x = k) =

∞

k=1

kmk−γ =

∞

k=1

1

kγ−m . (7.41)

For power-law networks, the epidemic threshold λ for the Susceptible–Infectious–Recovered (SIR)

and Susceptible–Infectious–Susceptible (SIS) epidemic models can be expressed as [112]

λ =

E

X

E

X2

  . (7.42)

The epidemic threshold is defined as the minimum ratio of infected nodes to the cured nodes per time

such that it still allows the epidemics to continue without outside infections. It follows that λ  → 0 if

γ ∈ (2, 3); in other words, such networks become infinitely susceptible to epidemic algorithms. This

property is very important for dissemination of control information in such networks.