Information Dissemination in a WSN: The Trickle Algorithm

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Information Dissemination

- Long lifetimes = re-tasking.
- Spectrum of re-tasking.
  - Binary images.
  - High-level virtual programs.
  - Parameter setting.
- Install on every node.
  - Packet loss.
  - Transient disconnection.
  - Nodes have correct code?

- Binaries: 10-60 kB.
- Virtual programs: 20-400 B.
- Parameters: 8-30 B.
- With 6LoWPAN, even larger!
- Multi-hop networks.
  - Reach every node.
Periodicity

- Checking if everyone has the right data can be expensive.
- Dissemination timing can lead to high costs.
- What is the appropriate transmission rate? *(density, RDC, mobility)*
- Idle network costs? *(re-transmissions, advertisements)*

- Continuously detect which nodes need updates.
- Maintenance cost should be near zero. *(suppress control messages)*
- Propagation should be rapid.
Solution: Trickle

- Time interval of length $\tau$.
- Redundancy constant $k$.
- Maintain a counter $c$.
  - Initialize to 0.
- Pick a time $t$ between $[0, \tau]$.
- At time $t$, broadcast code metadata if $c < k$.
- If you receive identical metadata, increment $c$.
- At end of $\tau$, pick a new $t$. 
Trickle Example

![Diagram showing trickle example with time axis and nodes labeled 1, 2, and 3. The diagram illustrates transmission and suppression of transmission with time interval \( \tau \).]
Trickle Example

\[ t_{1a} \]

\[ \tau \]

transmission  suppressed transmission  reception

1 2 3
Trickle Example

\[ t_{1a} \]

transmission

suppressed transmission

reception
Trickle Example

1. Transmission
2. Suppressed transmission
3. Reception
Trickle Example

\[ k = 1 \]

![Diagram showing the concept of trickle transmission](image)
Trickle Example

\[ k=1 \]

\[ c \]

1

2

3

\[ t_{1a} \]

\[ t_{2a} \]

\[ t_{3a} \]

\[ \tau \]

transmission

suppressed transmission

reception

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Trickle Example

\[ t_1^a \]
\[ t_2^a \]
\[ t_3^a \]

transmission
suppressed transmission
reception

\[ k=1 \]
Trickle Example

1. Transmission
2. Suppressed transmission
3. Reception

\[ k = 1 \]

- \( t_{1a} \)
- \( t_{2a} \)
- \( t_{2b} \)
- \( t_{3a} \)

Time \( \tau \)
Trickle Example

\[ k=1 \]

\[ \tau \]

\[ t_{1a} \quad t_{2a} \quad t_{2b} \quad t_{3a} \quad t_{3b} \]

transmission  suppressed transmission  reception
Trickle Example

1. Transmission
2. Suppressed transmission
3. Reception
Some nodes don’t listen often.

- Small $t$ values.

E.g., B transmits three times.
• Add a listening period.
  - Pick $t$ from $[0.5\tau, \tau]$. 
Choosing Intervals

- Large interval: *low cost, slow to propagate*.  
- Small interval: *high cost, quick to propagate*.

New gossip? *Talk more.*

Nothing new? *Talk less.*
Speeding Propagation

- Adjust $\tau$: $\tau_1$, $\tau_h$.
- When $\tau$ expires, double $\tau$ up to $\tau_h$.
- When you hear newer metadata, set $\tau$ to $\tau_1$.
- If you hear older metadata, send an update.

![Diagram showing the process of speeding propagation with time intervals $\tau_h$, $\tau_1$, and $\tau_h/2$.]
Conclusions

• Trickle efficiency scales logarithmically with density.
• Can obtain rapid propagation with low maintenance.
• Uses beyond code propagation.
  ▪ Changes to data such as routing tables
• What are the effects of changing $\tau_l$, $\tau_h$ and $k$?
