
Achieving Long-Term Surveillance in VigilNet

Infocom 2006

Presented by Chia-Yi Lien

Nov 10, 2006

Outline

- Introduction
- Requirements and Environment
- Key Power Management Strategies
 - Tripwire Services
 - Sentry Services
 - Sentry Duty Cycle Scheduling
- Simulation
- Conclusion

Introduction

- Besides requirements of accurate target tracking and classification, one of the key design goal of VigilNet is to achieve long-term surveillance.

Requirements and Environment

- Requirements
 - Rare and critical event detection
 - Flexibility
- Environment
 - Node density is high

Key Power Management Strategies

- There are three strategies, namely the tripwire service, sentry service and duty cycle scheduling.
- In order to support these strategies, all nodes must be able to find their own position.

Power Management Architecture

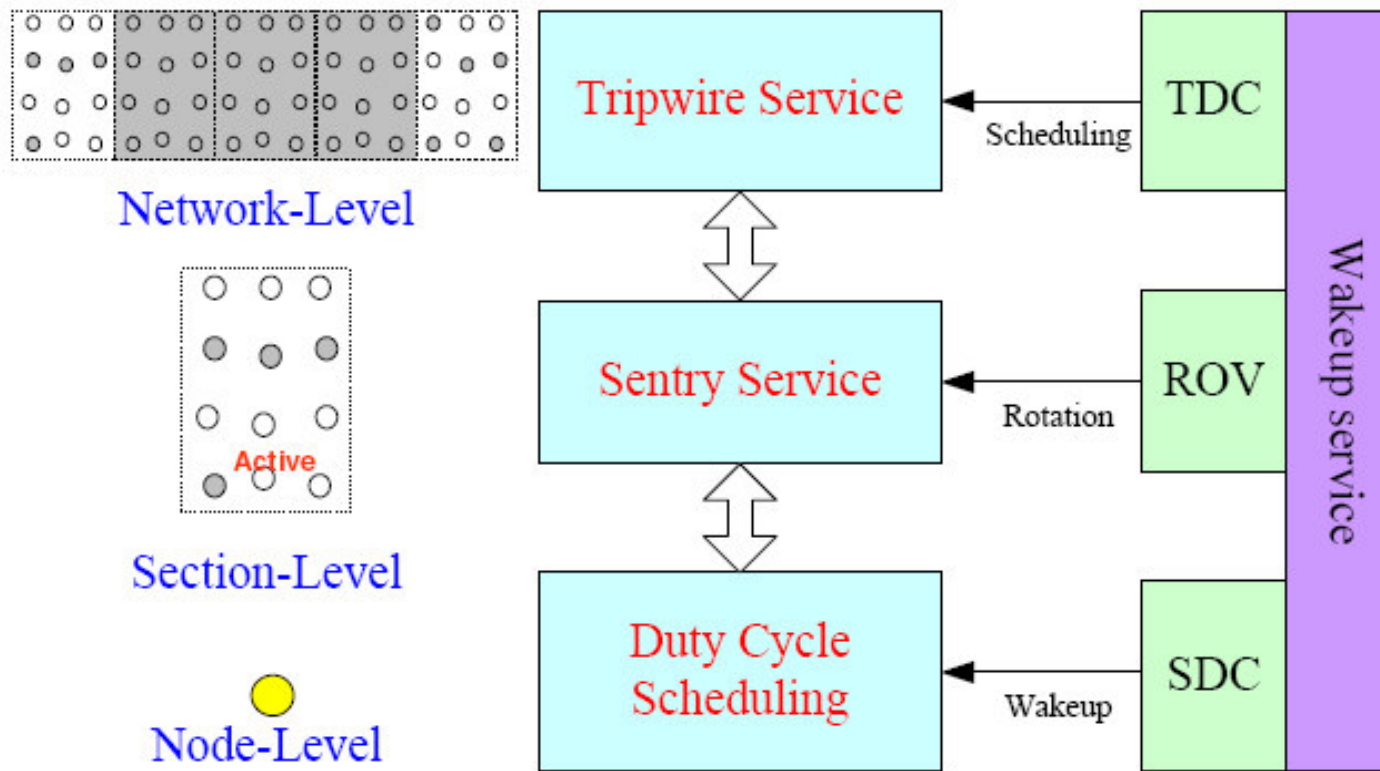
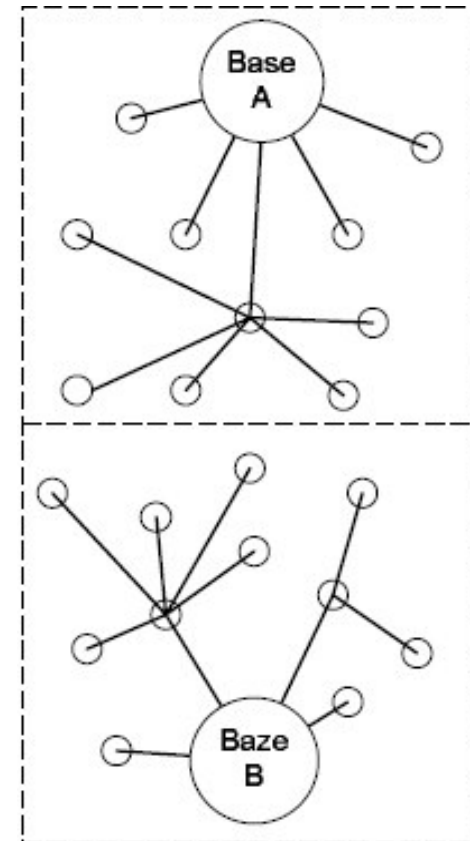


Fig. 3. Integrated PM Architecture

Tripwire Service

- The rationale behind the tripwire service is the existence of roads in the interest.
- Tripwire partition
 - A network with n bases is partitioned into n **tripwire sections**.
 - Partition by distance, routing by minimum hops
- Tripwire scheduling
 - **Tripwire duty cycle (TDC)**, which is the percentage of active rounds in the schedule.
 - Each section has its own scheduling.
 - TDC=50% → 1001, 1010



Sentry Service

- The rationale behind the sentry service is the high node density within the section.
- Sentry selection
 - Exchange its node ID, position, number of neighbors, and its own energy readings with neighbor
 - Build up a one-hop neighbor table
 - Declare itself as sentry
 - $$T_{timer} = \frac{W_e \times R_{energy} + W_c \times R_{cover}}{(W_e + W_c) \times \#Neighbors} MaxDelay + Jitter$$
 - Declaration range
 - Rotation

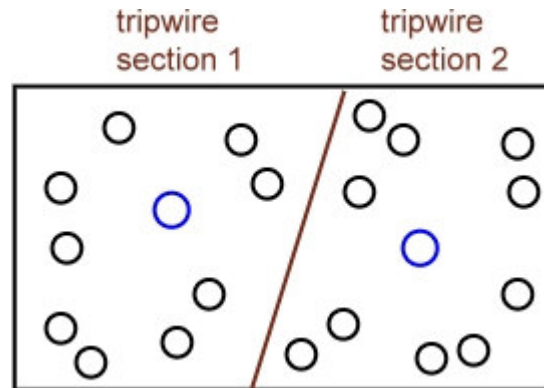
Sentry Duty Cycle Scheduling

- A target normally stays in the sensing area of a node for a non-negligible period of time.
- Periodically active
- Let T_{on} be the active duration and T_{off} be the inactive duration, then
 - Sentry Toggle Period (STP) = $T_{on} + T_{off}$
 - Sentry Duty Cycle (SDC) = T_{on} / STP

Integrated PM Strategies

1) tripwire service

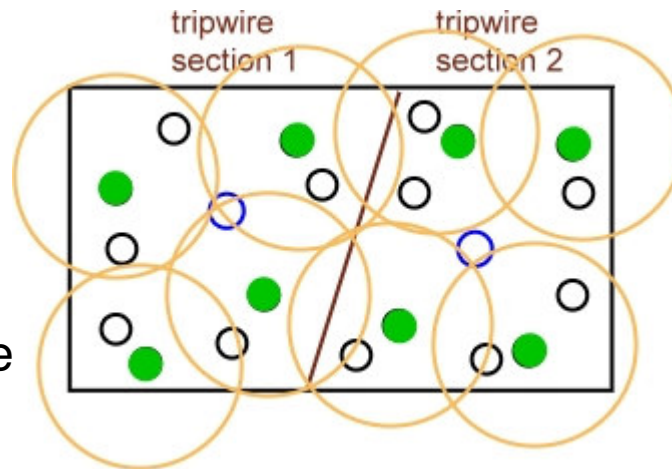
○ : base



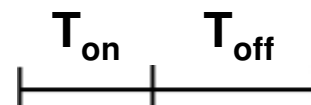
TDC = 100%

2) sentry service

● : sentry node



3) sentry duty cycle scheduling



$$\text{STP} = T_{\text{on}} + T_{\text{off}} \quad (1\text{s})$$
$$\text{SDC} = T_{\text{on}} / \text{STP} \quad (25\%)$$

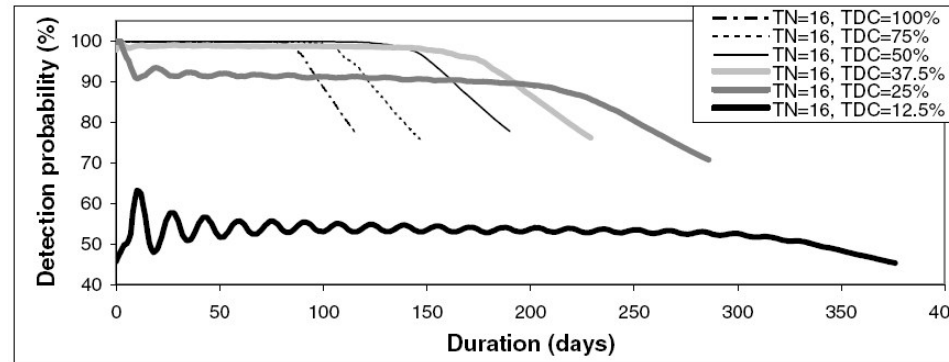
Simulation

- Distribute 10,000 nodes randomly within a 1000 x 1000 m² square.
- Parameter effect
- System key parameters

Parameter	Defi nition	Default Value
SDC	Sentry duty cycle (see IV-C)	25%
STP	Sentry toggle period (see IV-C)	1 second
SSA	Sentry service activation	True
TN	Number of tripwire partitions in the network	1
TDC	Tripwire duty cycle percentage (see IV-A.3)	100%
VS	Target Speed	4 m/s
RN	Number of system rotations per day	1
SR	Sensing Range	10 m
RR	Radio Range	30 m

TDC

1) tripwire duty cycle



default
TDC = 100%

Fig. 17. Influence of tripwire duty cycle (TDC) on detection probability (DP).

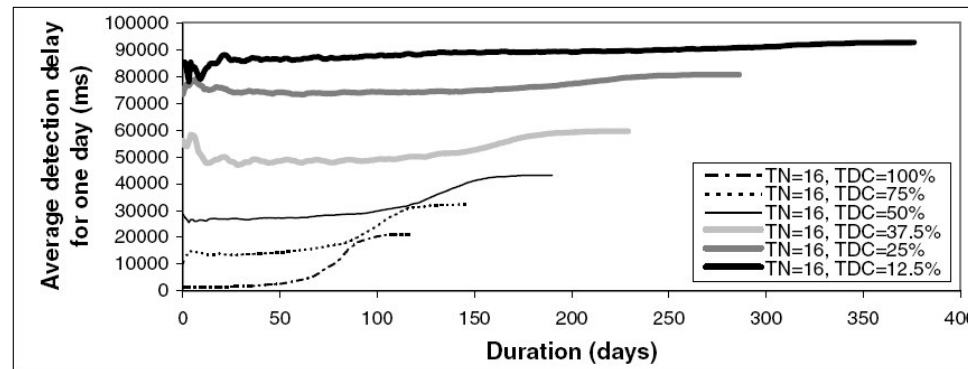


Fig. 18. Influence of tripwire duty cycle (TDC) on average detection delay (ADD).

SSA · SDC

Guidelines: Smaller SDC is better for lifetime.

2) sentry service

3) sentry duty cycle

default
SDC = 25%

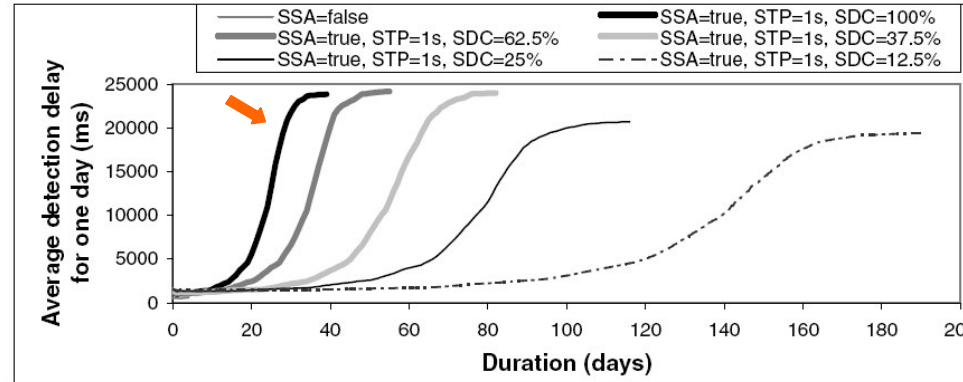


Fig. 12. Influence of sentry duty cycle (SDC) on average detection delay(ADD).

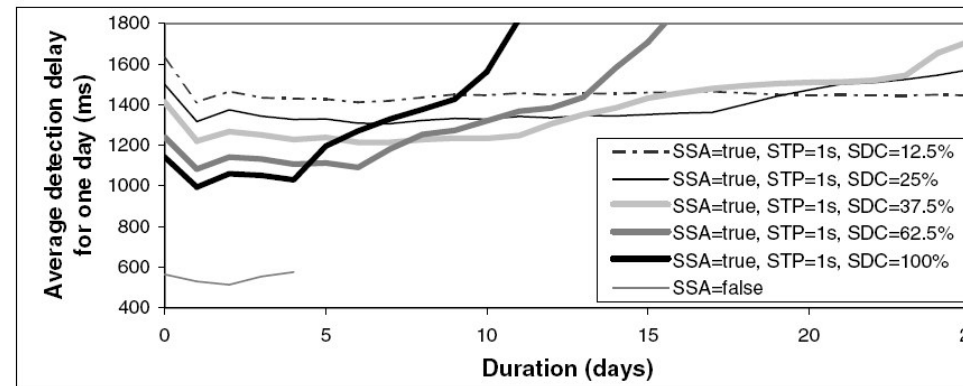


Fig. 13. Influence of sentry duty cycle (SDC) on average detection delay (ADD) (the second view)

STP

3) sentry toggle period

Guidelines: Smaller STP is better for detection delay.
Need rapid sensor wakeup and quick target detection algorithm.

default
STP = 1s

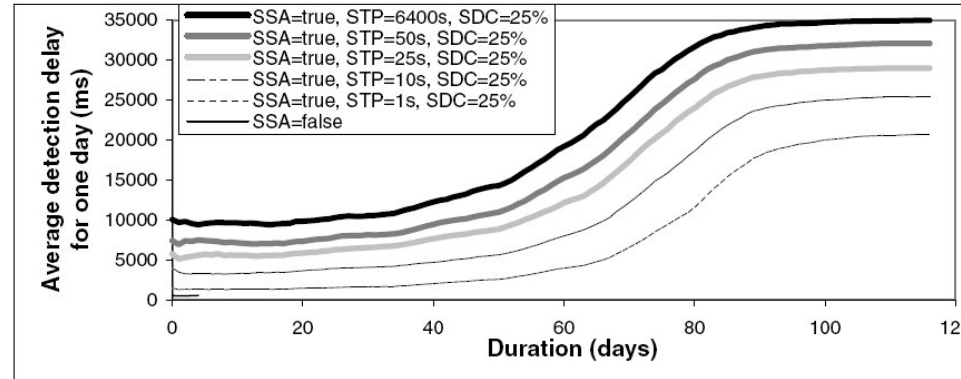


Fig. 15. Influence of sentry toggle period (STP) on average detection delay (ADD).

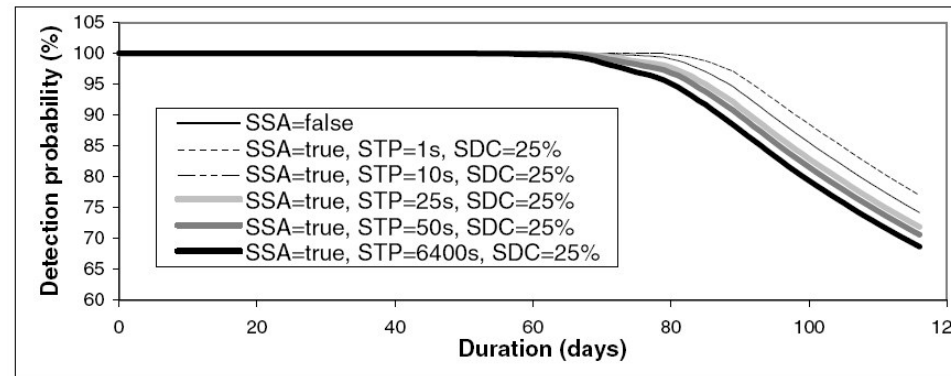
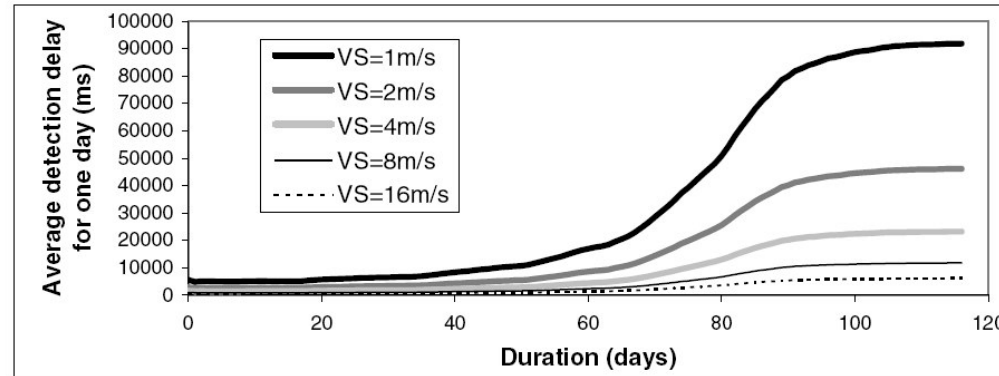


Fig. 16. Influence of sentry toggle period (STP) on detection delay (DP).

Target Speed

Guidelines: network characteristics defined in this experiment can handle target with speed up to 16m/s.



default
VS = 4m/s

Fig. 19. Influence of target speed (VS) on average detection delay (ADD).

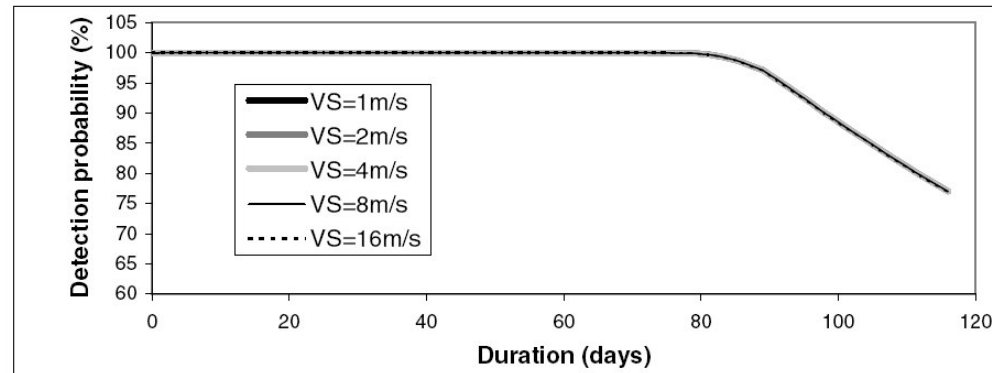


Fig. 20. Influence of target speed (VS) on detection probability (DP).

Conclusion

- VigilNet can achieve long-term surveillance.
- We can tune the parameter to adapt to different environment, so VigilNet is flexible.
- We identify several useful guidelines for future research.
 - To reduce the detection delay, we choose a small STP.
 - To increase the network lifetime, we select a small SDC.