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CLUSTERING METHOD MODIFICATION FOR CONTINUOUS MONITORING IN WIRELESS SENSOR NETWORKS

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МОДИФІКАЦІЯ МЕТОДУ КЛАСТЕРИЗАЦІЇ ДЛЯ БЕЗПЕРЕРВНОГО МОНІТОРИНГУ В БЕЗПРОВІДНИХ СЕНСОРНИХ МЕРЕЖАХ

У статті описується модифікація методу кластеризації сенсорних мереж, що здійснюють постійний нагляд за активними подіями, головна ідея якої полягає у використані поняття прилеглих, суміжних датчиків, взаємно покриваючих зон моніторингу при побудові кластерів для підвищення достовірності отриманої інформації та енергоефективності усієї мережі.

Energy efficiency increasing is the most important issue for wireless sensor networks, which is composed by sensor devices purely limited in power. Solution of this problem were presented in different articles, most of them – by clustering method usage and its modification [1].

But the main aim of monitoring applications built on the grounds of wireless sensor networks is to detect some event and send actual and accurate information to users with minimally possible energy consumption. More often than not the detected event may spread to a larger region or/and may change its location (Figure 1, a-b).

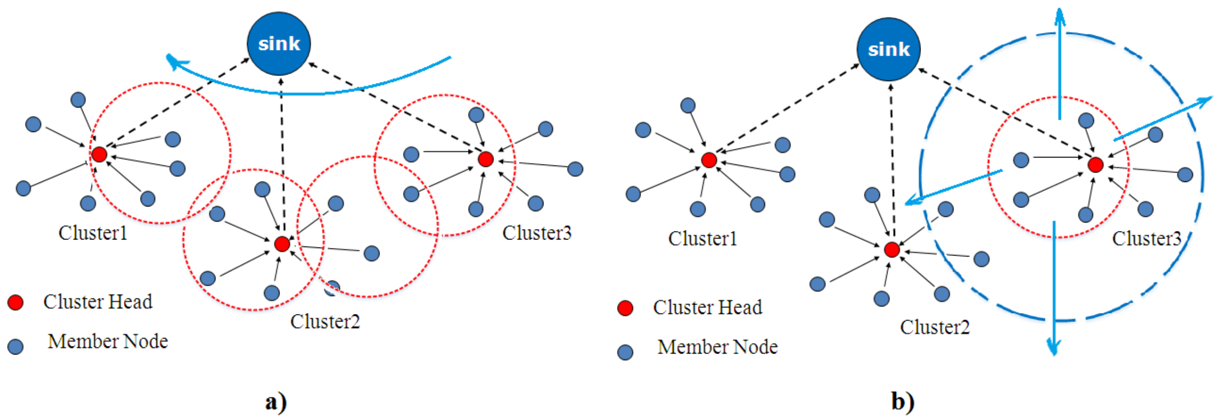


Fig. 1. Event migration (a) and extension (b) example

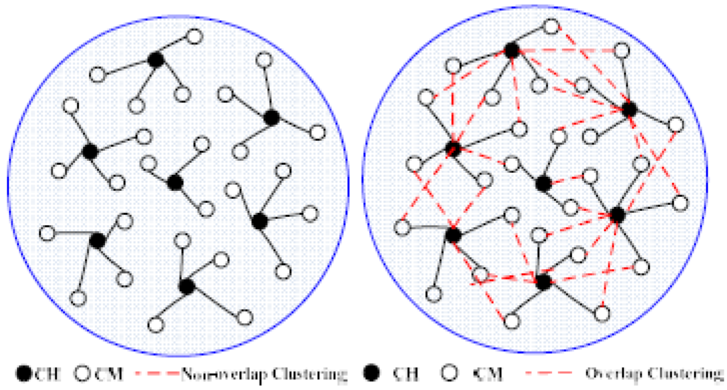
So it is needed to propose such modification of existed clustering method, which will be focused on continuous monitoring with possibly event fluctuation.

Modification in the form of an energy-efficient 2-logical-coverage overlapping clustering is described in this article. It is designed to adapt to event fluctuation, which ensures that data collected by adjacent sensors in the event area are sent to the same CHs for fusion. Once the event spreads to neighboring regions, a collaborative

CH re-adjustment and cluster migration technique is used to ensure effective cluster formation associated with a 2-logical overlapping clustering.

Both single-hop (LEACH) [2] and multi-hop (hierarchical cluster-based routing algorithm, DEECIC) [3] clusters are formed independent of event developments, which are not suitable for dynamic continuous monitoring applications.

In proposed modification, a novel 2-logical-coverage cluster formation scheme and cluster migration scheme are designed to form and activate proper clusters according to event development. The overlapping cluster formation operation is illustrated in Figure 2. Firstly, non-overlap clusters are formed similar to traditional cluster formation schemes, as in Figure 2 (a). Secondly, each node chooses the next-closest cluster head (CH) to form the 2-logical-coverage overlapping clusters, as in Figure 2 (b).



(a)Non-overlap cluster formation (b) Overlap cluster formation

Fig. 2. Cluster formation with 2-logical coverage overlaps

Whole network is divided into 2-logical-coverage subnets - each node belongs to two adjacent clusters simultaneously. The role of boundary nodes includes two aspects: as 1-hop forwarding nodes when the single hop clusters are combined into 2-hop clusters; as alarm nodes to indicate the moving direction of the event.

Cluster migration step with event moving and expanding is provided the next way - for cluster i, suppose the number of boundary nodes in its u_{th} (u = 1, 2, ..., k_0) overlapping area is $m^u{}_i$, the reading of the p^{th} sensor at the sampling instant t is $r_p(t)$. Hence, the difference of average reading at the adjacent sampling instant t and (t+1) in the u_{th} overlapping area (denoted as $\Delta r_u(t+1)$) is

$$\Delta r_u(t+1) = \frac{1}{m_i^u}\sum_{p=1}^{m_i^u}(r_p(t+1) - r_p(t)). \tag{1}$$

The difference of average reading at sampling instant t between the u_{th} and v_{th} overlapping areas in cluster i (denoted as $\Delta q_{uv}(t)$) is

$$\Delta q_{uv}(t) = \frac{1}{m_i^u}\sum_{p=1}^{m_i^u} r_p^u(t) - \frac{1}{m_i^v}\sum_{p=1}^{m_i^v} r_p^v(t). \tag{2}$$

The parameter Δr_u indicates whether the detected event will expand. When the reading of a sensor is above lower boundary value r_0, an event is detected in the network. If Δr_u decreases continuously, the event may disappear sooner. Most of the sensors in these areas will go into the sleep mode while a few of them transmit the sensed data at a low frequency for network connectivity. The parameter Δq_{uv} indicates the motion direction of the event. If Δq_{uv} decreases continuously, it means that the event will move to the adjacent cluster and all sensors of it should go to active monitoring mode.

When the event spreads to a larger area, the adjacent 1-hop clusters are combined into a 2-hop cluster via the boundary nodes. As shown in Figure 3, at the beginning, the event area is covered by the blue chain line cluster. Once the event spreads to a larger area, the three green dotted line clusters will combine with the blue one to form a 2-hop cluster. The nodes can communicate with CH directly or through the nearest boundary nodes. The boundary nodes aggregate the forwarding data and send it to CHs. If the event spreads to an even larger region, more than one 2-hop clusters are combined to ensure all the event development is detected.

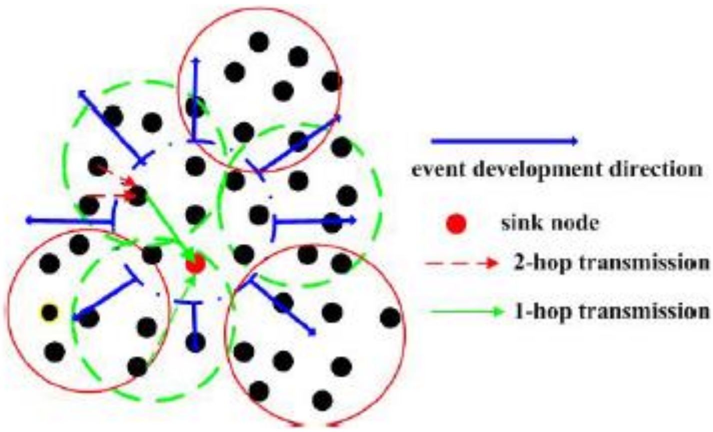


Fig. 3. Cluster migration with event expansion

Conclusion. In this paper, a clustering method modification for dynamic continuous monitoring applications is presented. The modification is that the event-based cluster migration technique is used to activate appropriate clusters for continuous monitoring via the 2-logical-overlapping clustering scheme. As a result, the cluster topology can be switched according to the event development with low energy consumption. It is concluded that the such modification provides clustering protocol to be more suitable for the dynamic continuous monitoring and more energy-efficient in comparison with other existing ones.

References

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