

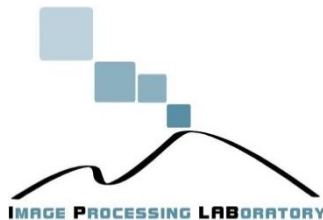
RECFusion

RECFusion: Automatic Scene Clustering and Tracking in Videos from Multiple Sources

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WAVE

Wireless Applications in multi-deVice Ecosystems

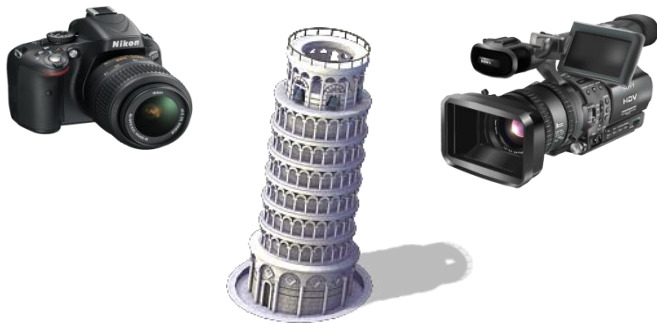
Overview

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Motivations

- The automatic processing of video data from many devices, as smartphones, tablets, webcams, surveillance cameras, etc., in the real-time context is not a trivial issue

Cultural Heritage



Assistive Technology



Social Media



Main Aims

1. Analysis of video streams from multi-source multi-device context
2. Identification of the **scenes of interest** through clustering of video sequences
3. Time tracking of the computed scenes clusters



Notation

 f_{v_k, t_n}

- Denotes a frame from video stream (device) v_k at time-slot t_n

 S_{ID, v_k, t_n}

- Output of **Intra-flow classification**: denotes a *scene* identified by a $Scene_{ID}$ from video stream (device) v_k at time-slot t_n

 C_{ID, v_k, t_n}

- Output of **Inter-flow classification**: denotes a *scene* identified by a $Cluster_{ID}$ from video stream (device) v_k at time-slot t_n

 L_{ID, v_k, t_n}

- Output of **Cluster Tracking**: denotes a *cluster* identified by a $LoggedCluster_{ID}$ from video stream (device) v_k at time-slot t_n

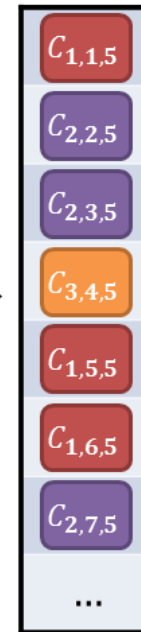
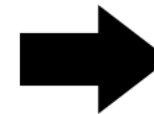
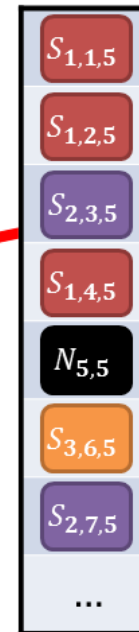
Intra- and Inter-flow Classifications

INTRA-FLOW CLASSIFICATION OF d_6



FROM INTRA- TO INTER-FLOW CLASSIFICATION AT t_5

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	...
d_1	$f_{1,1}$	$f_{1,2}$	$f_{1,3}$	$f_{1,4}$	$f_{1,5}$	$f_{1,6}$	$f_{1,7}$	$f_{1,8}$	$f_{1,9}$...
d_2	$f_{2,1}$	$f_{2,2}$	$f_{2,3}$	$f_{2,4}$	$f_{2,5}$	$f_{2,6}$	$f_{2,7}$	$f_{2,8}$	$f_{2,9}$...
d_3	$f_{3,1}$	$f_{3,2}$	$f_{3,3}$	$f_{3,4}$	$f_{3,5}$	$f_{3,6}$	/	/	/	...
d_4	$f_{4,1}$	$f_{4,2}$	$f_{4,3}$	$f_{4,4}$	$f_{4,5}$	$f_{4,6}$	$f_{4,7}$	$f_{4,8}$	$f_{4,9}$...
d_5	$f_{5,1}$	$f_{5,2}$	$f_{5,3}$	$f_{5,4}$	$f_{5,5}$	$f_{5,6}$	$f_{5,7}$	$f_{5,8}$	$f_{5,9}$...
d_6	$f_{6,1}$	$f_{6,2}$	$f_{6,3}$	$f_{6,4}$	$f_{6,5}$	$f_{6,6}$	$f_{6,7}$	/	/	...
d_7	$f_{7,1}$	$f_{7,2}$	$f_{7,3}$	$f_{7,4}$	$f_{7,5}$	$f_{7,6}$	$f_{7,7}$	$f_{7,8}$	$f_{7,9}$...
...



Why Cluster Tracking?

- **Intra-flow Classification:**

- The $Scene_{IDs}$ are related to a single video stream. Frames labeled with the same $Scene_{ID}$ but taken from different video streams could definitely represent different scenes!

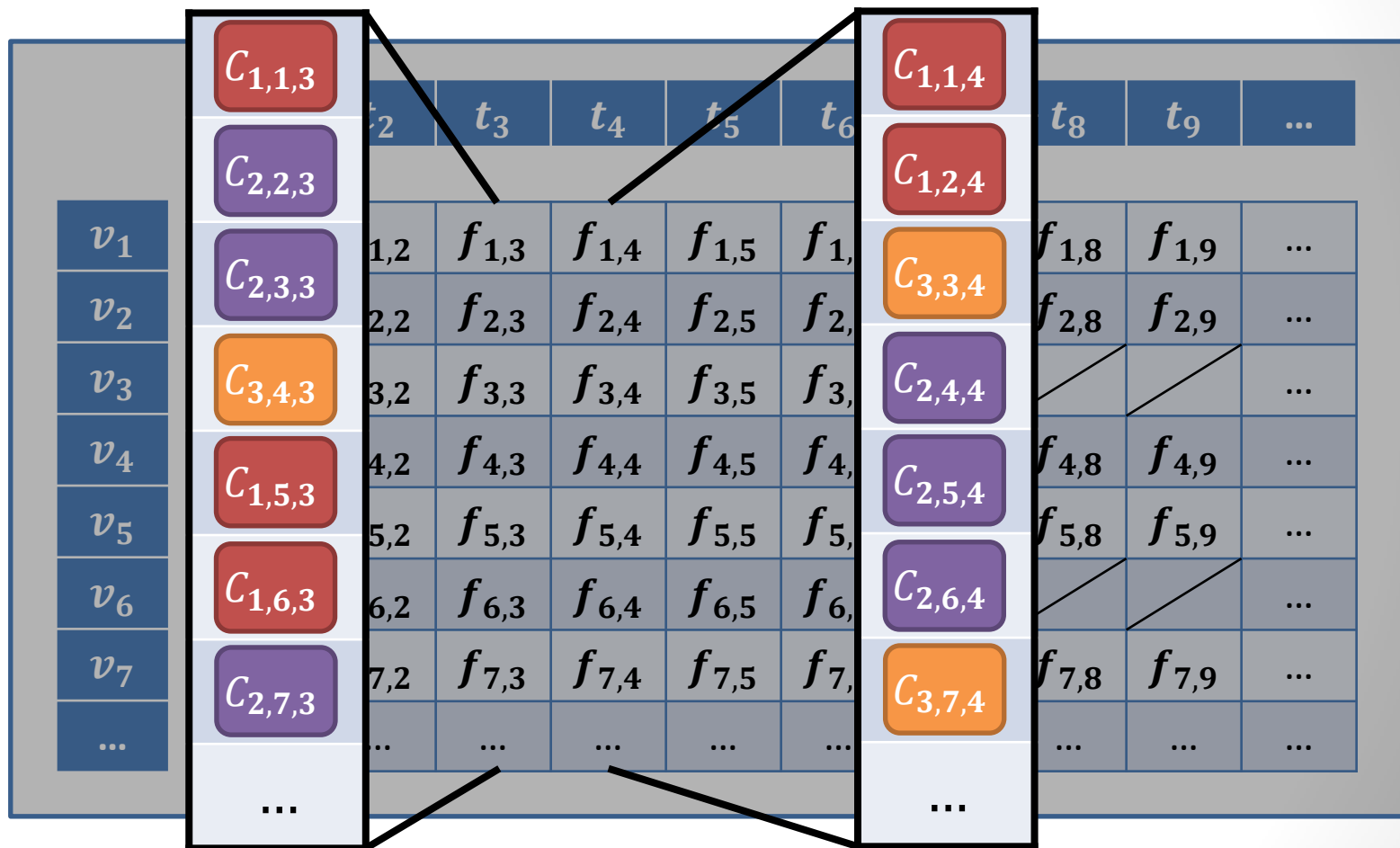
- **Inter-flow Classification:**

- The $Cluster_{IDs}$ are related to a single time-slot. Frames labeled with the same $Cluster_{ID}$ but taken from different time-slots could definitely represent different scenes!

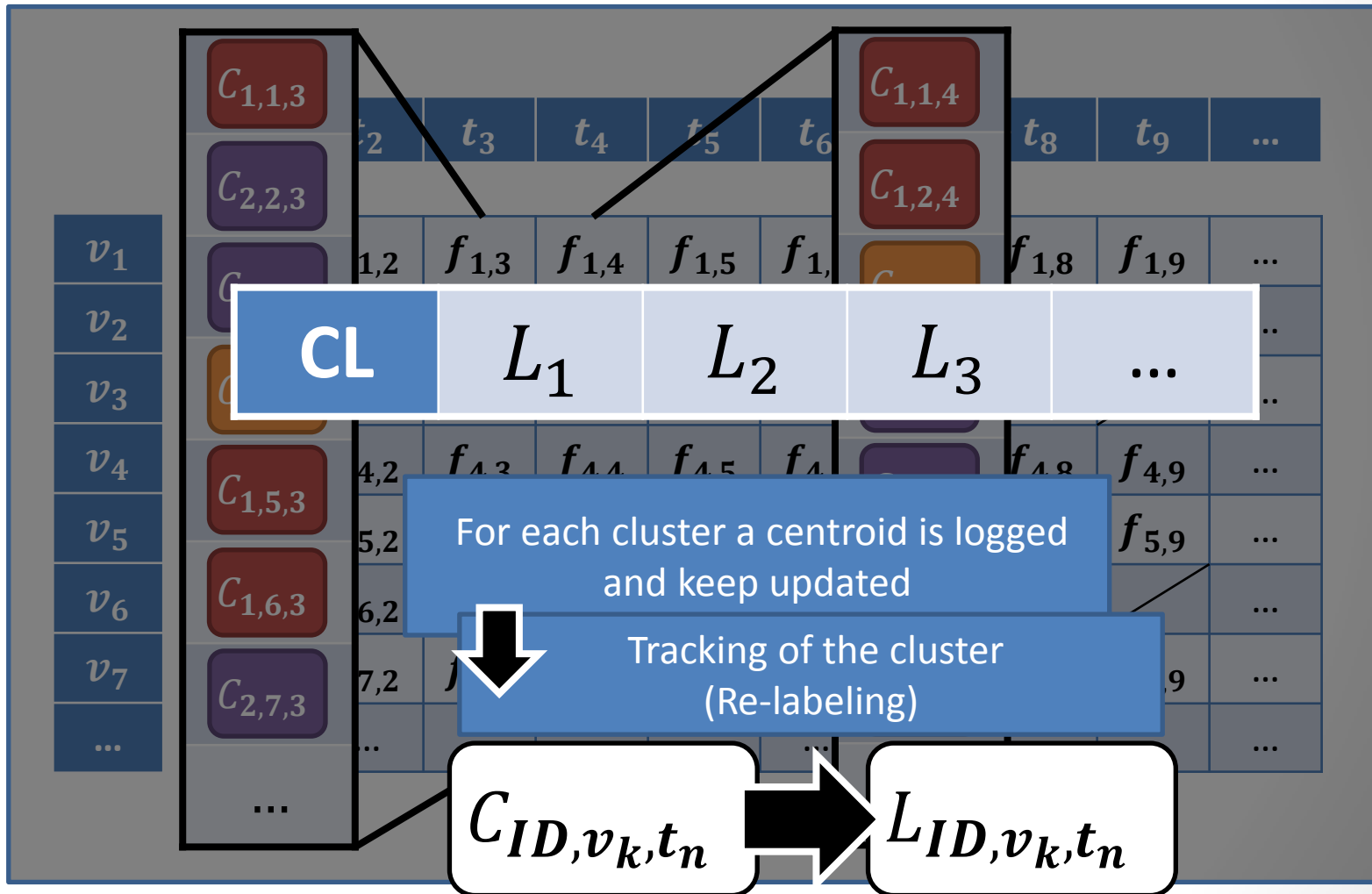
- **Cluster Tracking:**

- $LoggedCluster_{IDs}$ are related to the whole dataset of video streams: they represent the same scene in every time-slot!

Cluster Tracking (1)

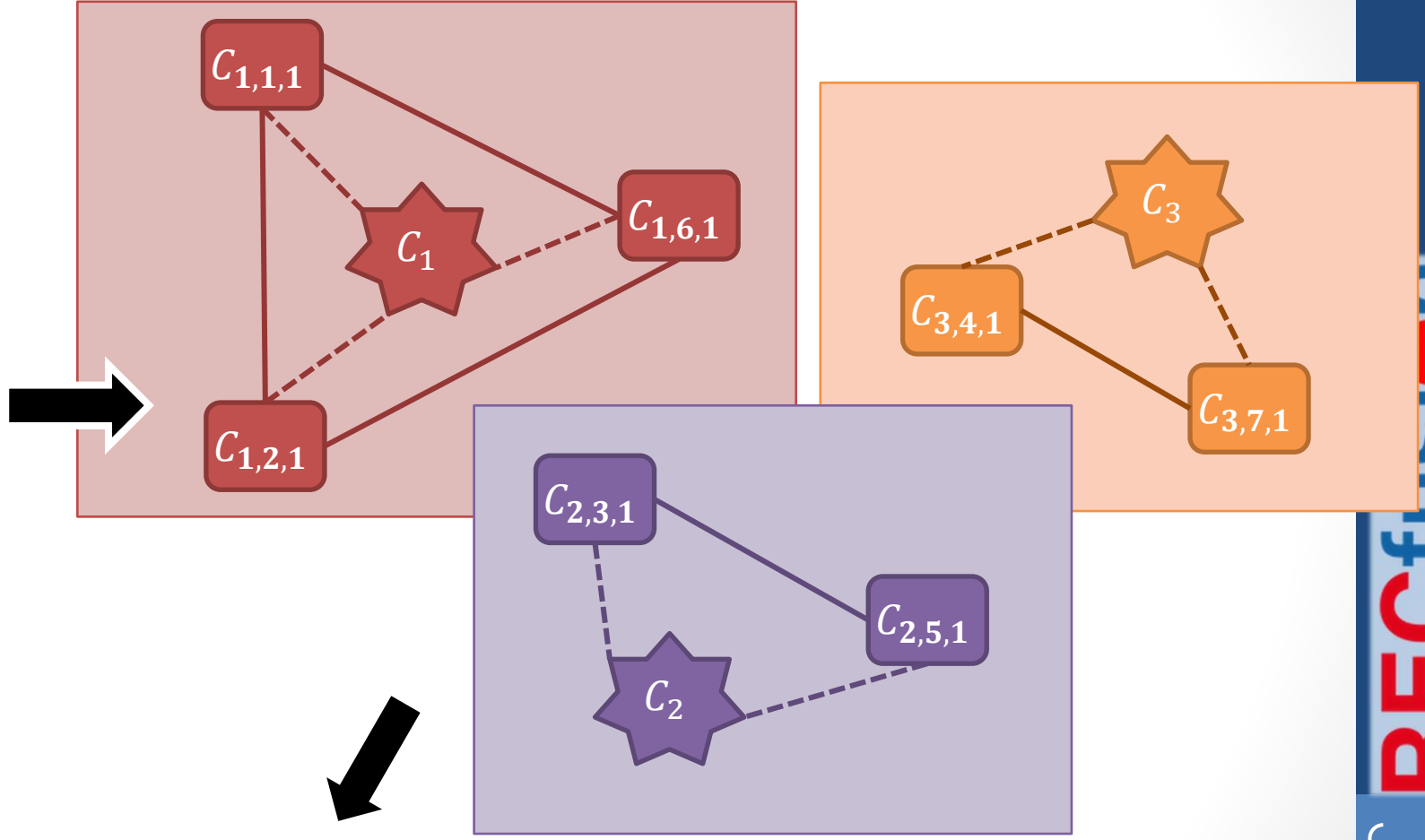
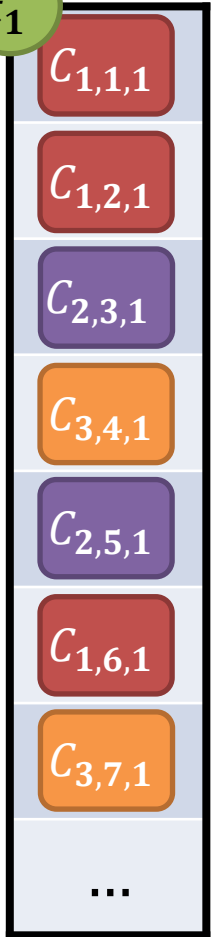


Cluster Tracking (2) – Cluster Log

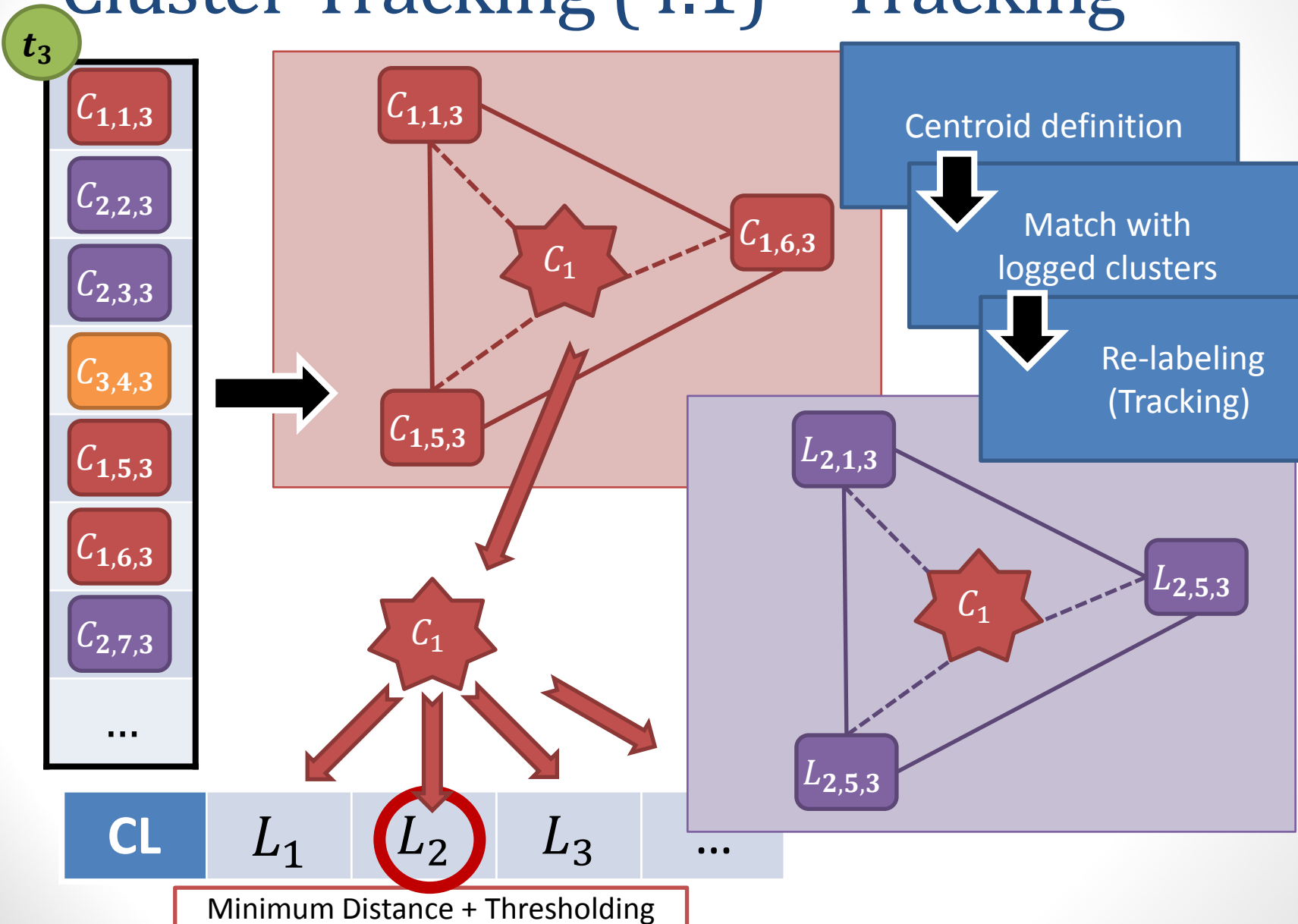


Cluster Tracking (3) – Initialization

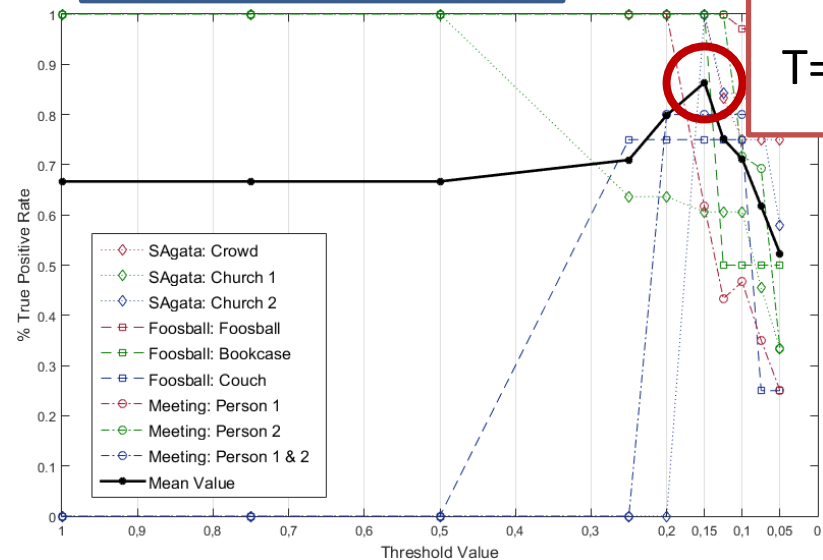
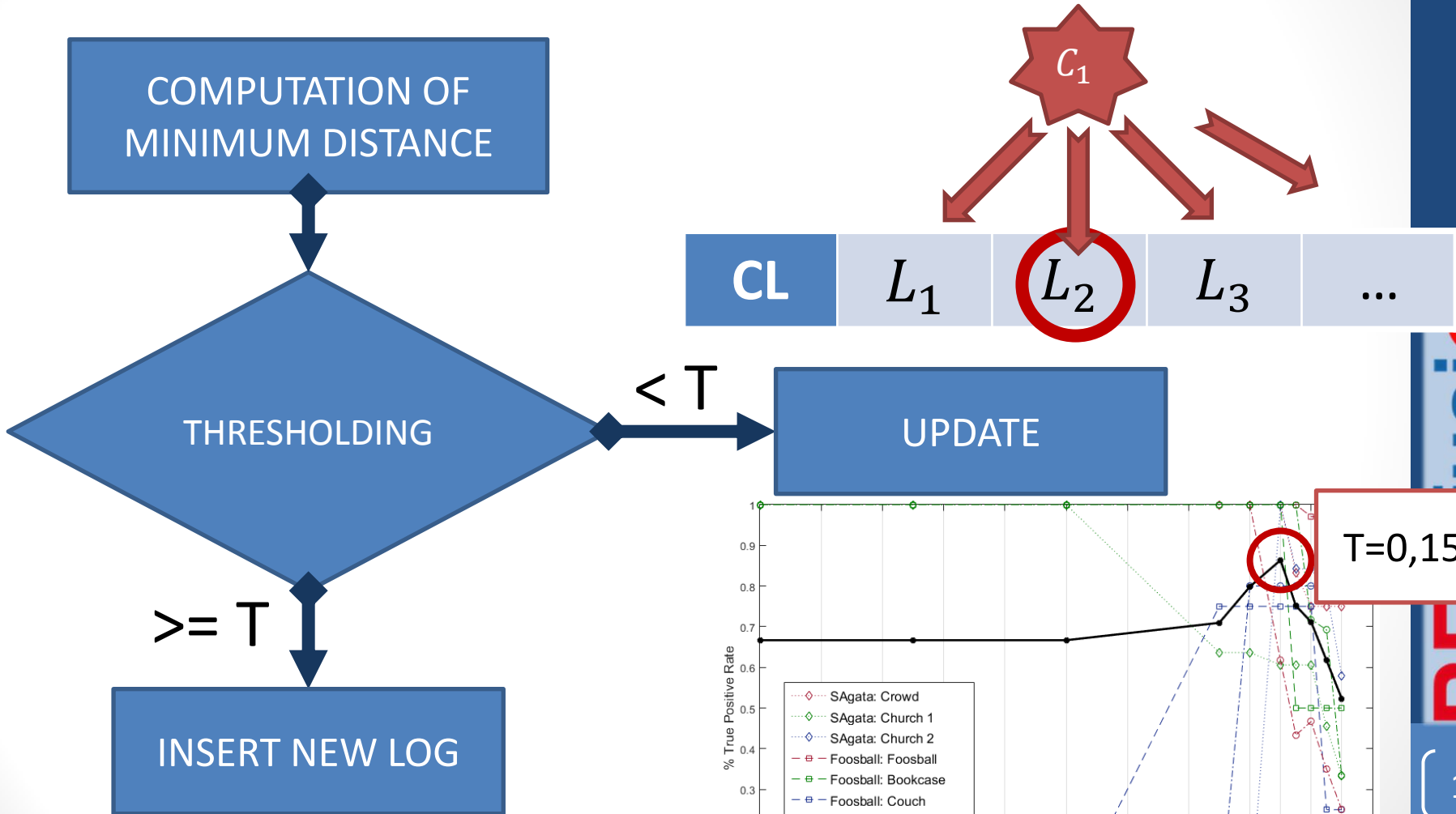
t_1



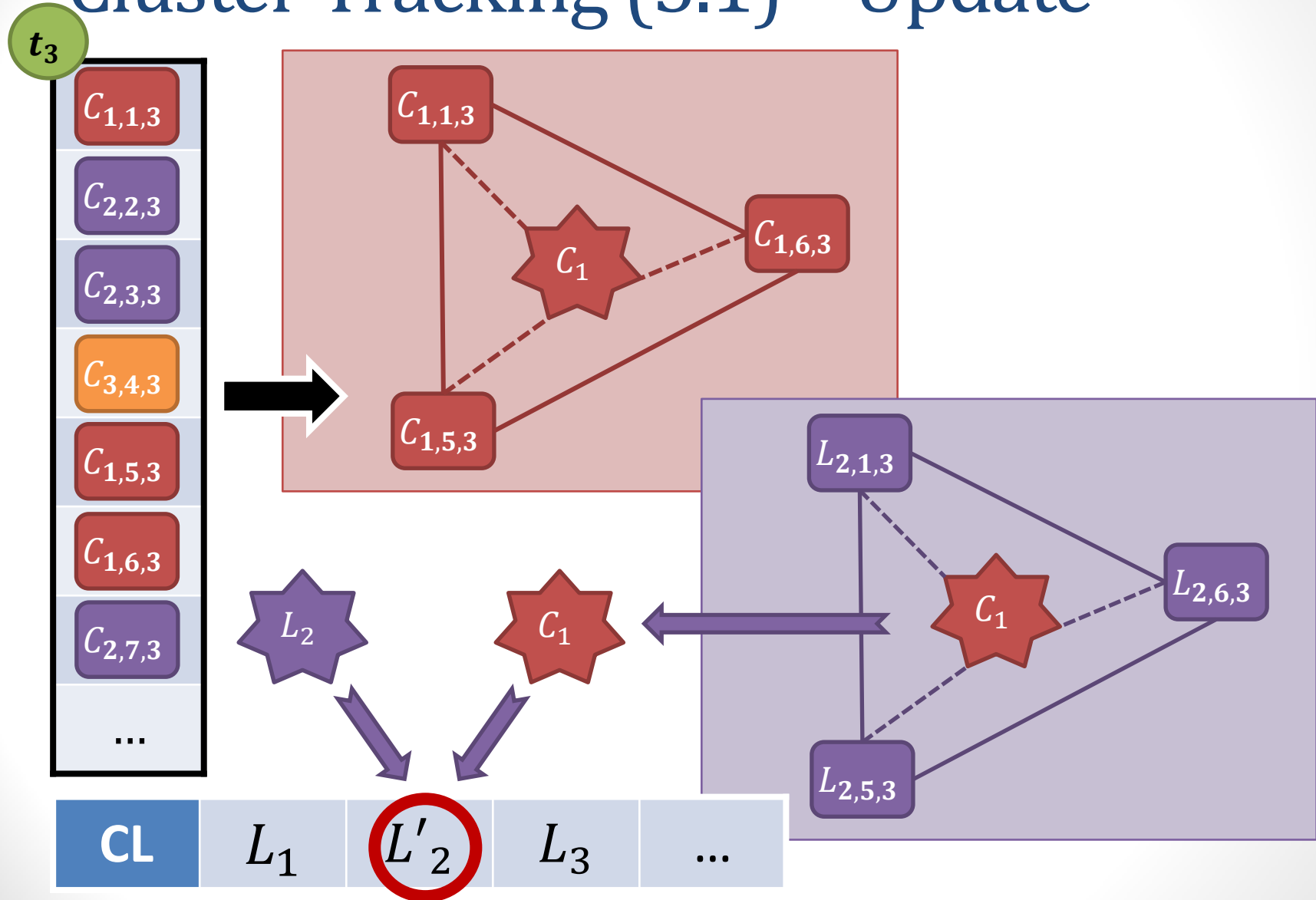
Cluster Tracking (4.1) – Tracking



Cluster Tracking (4.2) – Tracking



Cluster Tracking (5.1) – Update



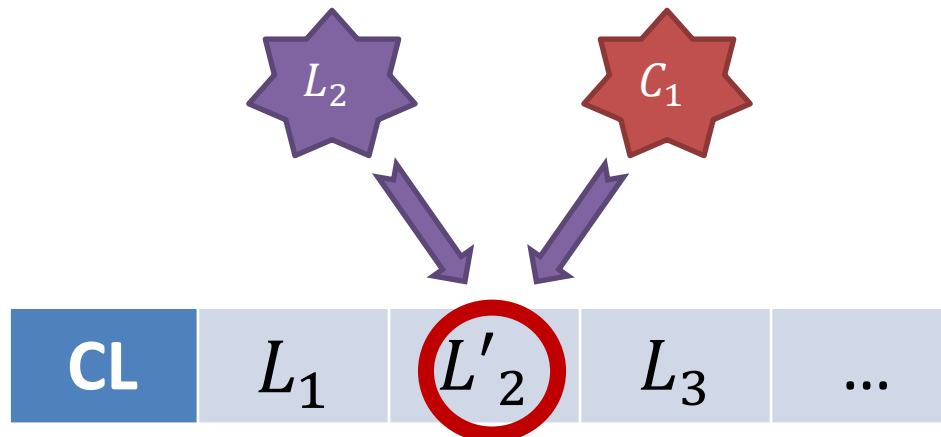
Cluster Tracking (5.2) – Update

Weighted Update:

- Logs become even more stable after each update

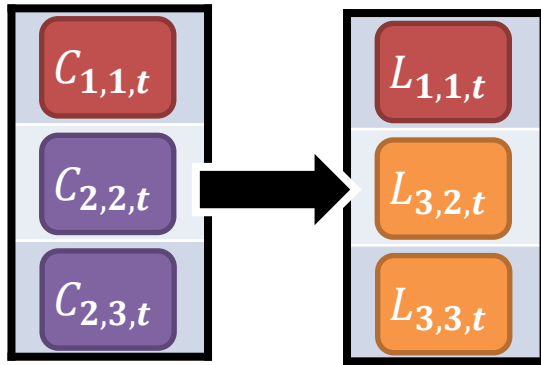
$$L'_a = \frac{u}{u+1} L_a + \frac{1}{u+1} C_b$$

- Where u is the number of updates performed, increased by 1 to take into account also the insertion

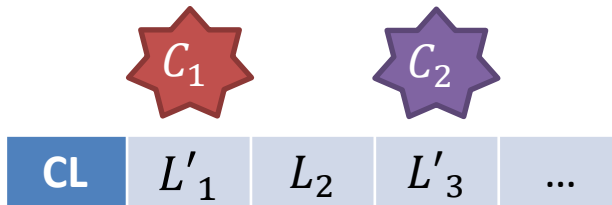


Cluster Tracking (5.3) – Update

#Cluster ≤ #LoggedCluster

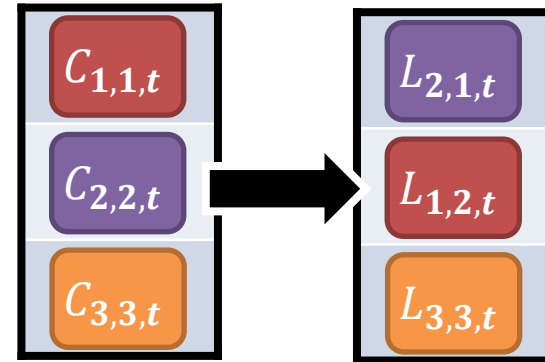


Update:

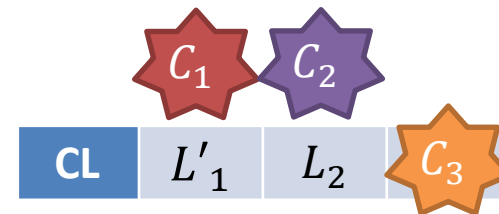


New log(s) could be defined

#Cluster > #LoggedCluster

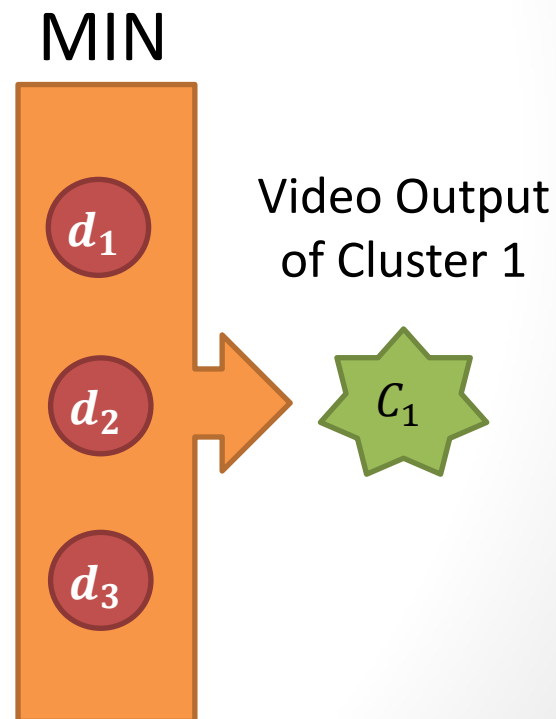
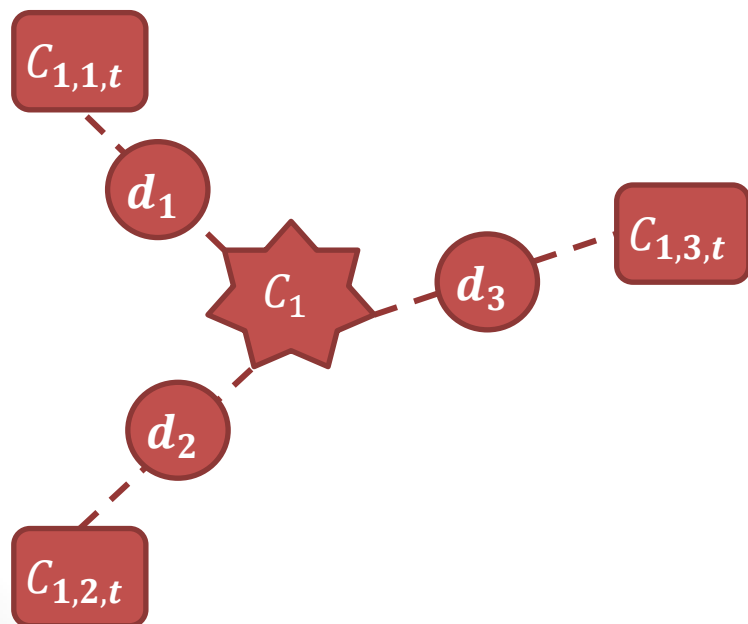
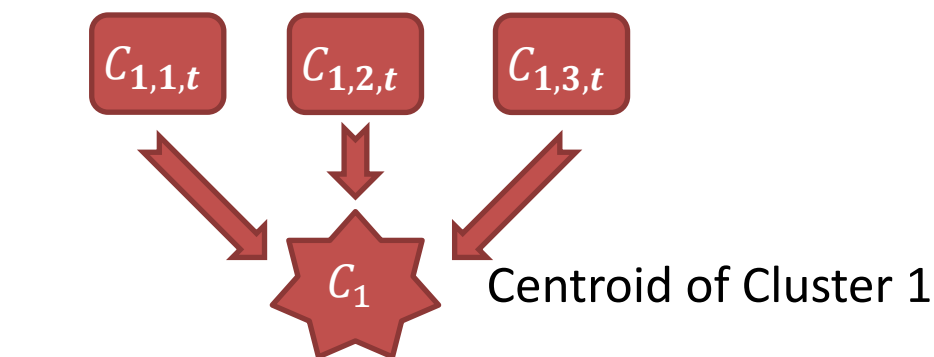


Update:

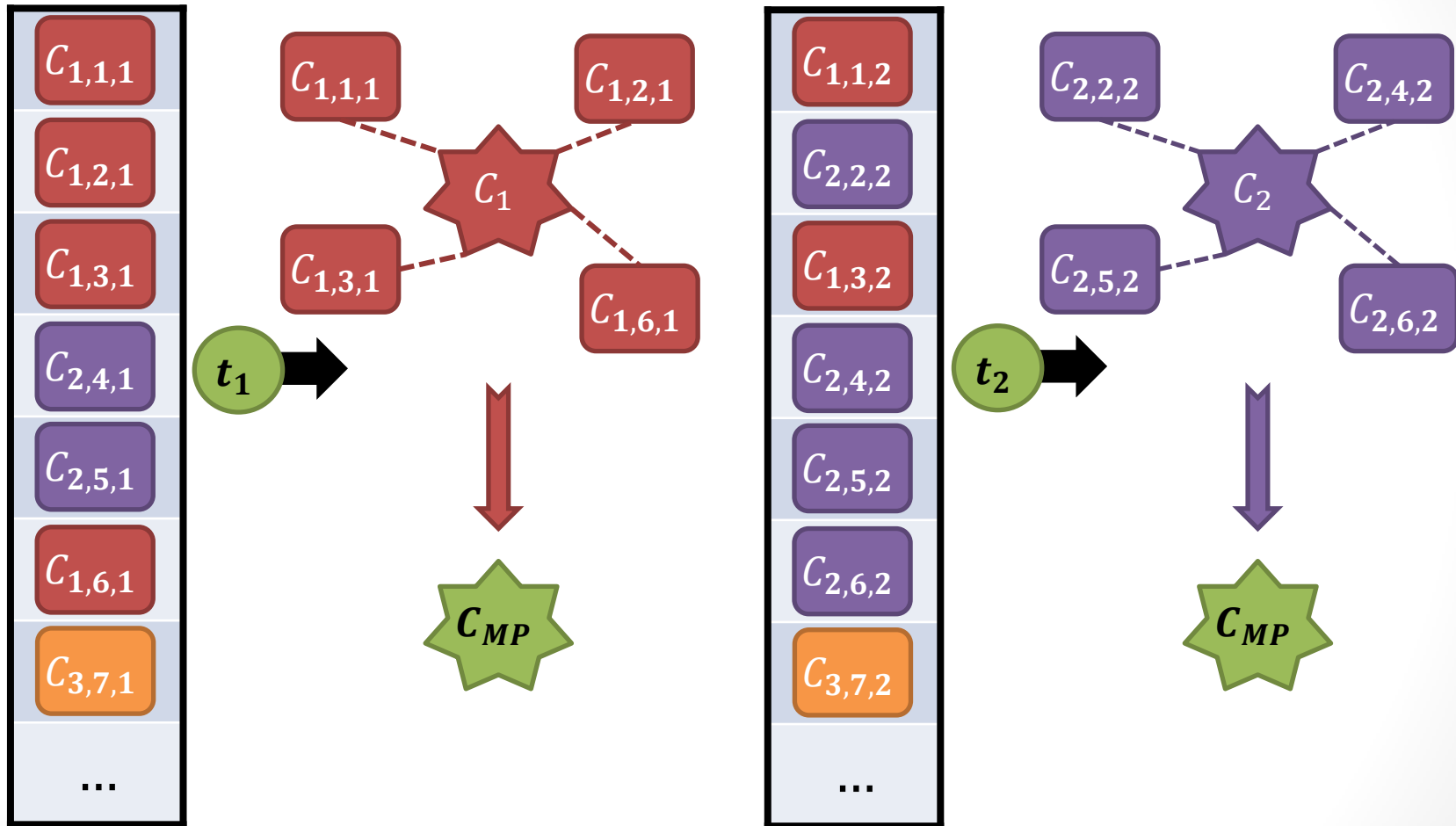


New log(s) will be defined

Most Representative Frame of a Cluster at time t : Frame with minimum distance from Cluster Centroid

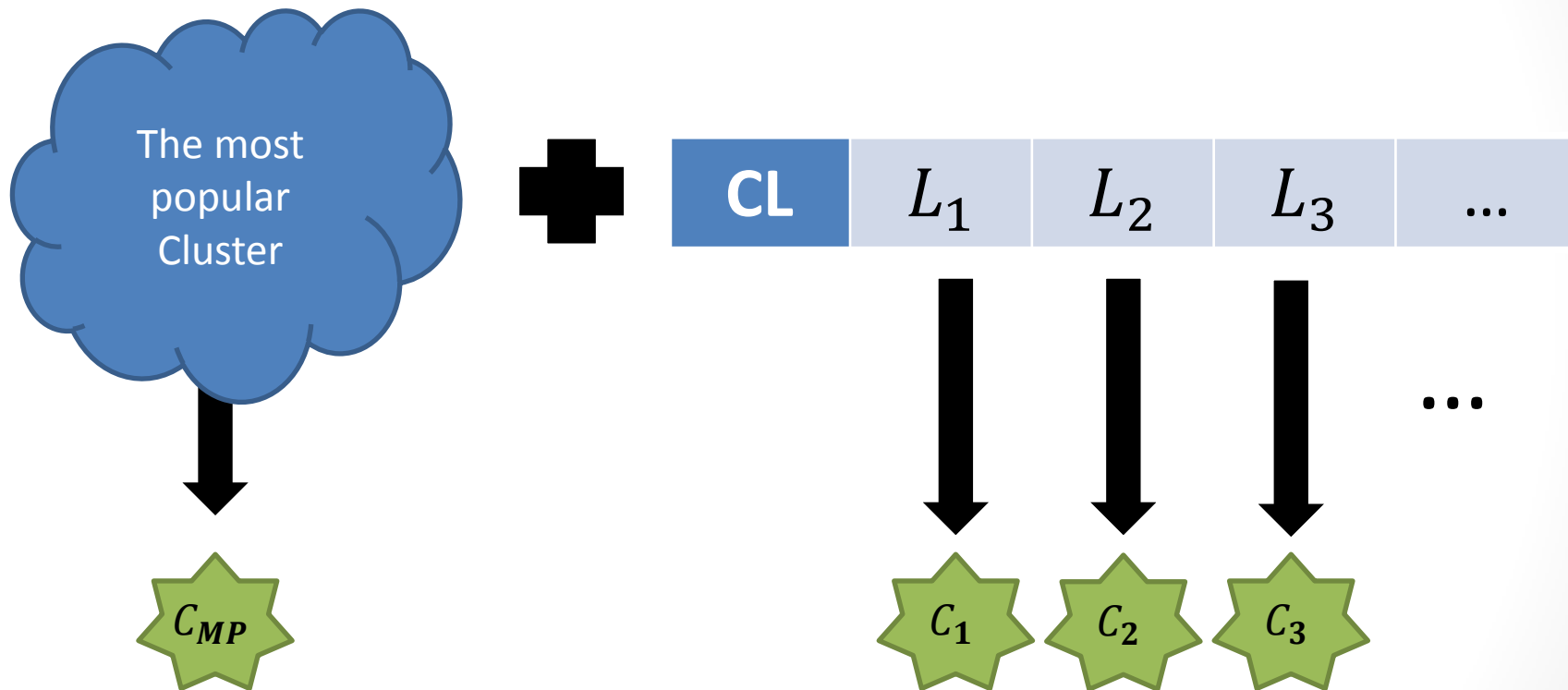


Selection of most representative frame: Behaviour of previous RECFusion version



For each time slot t_n a single representative frame is computed from the most popular (the biggest) cluster

Selection of most representative frame (1): RECFusion + Cluster Tracking



Selection of most representative frame (2): RECFusion + Cluster Tracking



<http://recfusionproject.altervista.org/clustertracking.htm>

Demo



<http://recfusionproject.altervista.org/clustertracking.htm>

Demo in a glance



Conclusion

- We have presented an extension to RECfusion:
 - **Cluster Tracking** has been added:
 - The different scenes within the collection are identified. They could be all selected and tracked in the whole collection of video-streams by multi-source devices, and might be used in the output video.
 - Previously, only the most popular cluster for each time-slot was used in the output video.
 - An evaluation of a **better threshold for LoggedClusters update** has been conducted:
 - Experimentations assess the goodness of the threshold equal to **0,15**

Future Works

Assistive Technology

- We are planning to add some other functionalities:
 - **Assistive Technology:**
 - Exploiting wearable devices
 - 'How much time have I spent in a specific room?'



- **Security & Computer Forensics:**
 - it might give an advice on when the scenario is subject to some changes



RECFusion related publications

- A. Ortis, G. M. Farinella, V. D'Amico, L. Addesso, G. Torrisi, S. Battiato, RECFusion: Automatic video curation driven by visual content popularity, in: ACM Multimedia, ACM MM 2015, 2015, pp. 1179-1182.
- F. L. M. Milotta, S. Battiato, F. Stanco, V. D'Amico, G. Torrisi, L. Addesso, RECFusion: Automatic scene clustering and tracking in video from multiple sources, in: EI - Mobile Devices and Multimedia: Enabling Technologies, Algorithms, and Applications 2016, IS&T, 2016.
- Further extension is in progress...

<http://recfusionproject.altervista.org/>

Thanks!

Any question?

<http://recfusionproject.altervista.org/>