ITK Video

ITK Extensions for Video Processing

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Real-Time Image Capture for ITK through a Video Grabber

Kevin Cleary

Methods in Medical Image Analysis: An ITK-Based Course with Deliverable Algorithms that extends and evaluates ITK while broadening its developer base

John Galeotti

Goal

- Make video a first-class citizen of ITK
  - Video I/O
- Allow ITK to be used with Computer Vision libraries (OpenCV, vxl, etc.)
- Allow other libraries to be used with ITK
  - Implement ITK filters using other libraries
- Ensure framework allows real-world video problems to be *researched*
  - E.g. don't try solve hard real-time, but make sure real-time issues can be solved

Assumptions and Choices

- Time is not another dimension
  - Video != 3-d pixel volume
  - Unbounded (live cameras)
  - Memory (2 hrs 1920x1080 color video = 44 GB)
  - On-line processing (streaming applications)
    - We haven't invented time travel yet
- No explicit tagging of color spaces and other metadata (except for time)
  - Video readers will produce grayscale or RGB
  - Similar to CT and Hounsfield

Status: Real-time capture

- Using avacap for frame grabbing (GPL)
  - Created an ITK version which is not GPL
- Ring buffer implemented (duplicated)

Status: Video Extensions

- 4-hr tutorial at CVPR
  - Presented: ITK; using ITK with OpenCV; using OpenCV with ITK; direct video support in ITK
  - ~33 people stayed for whole session
  - Raffle ticket histogram:
    - 1: 22
    - 2: 6
    - 3: 15
    - 4: 5
    - 5: 7
    - 6: 4
    - 7: 2

Video in ITK

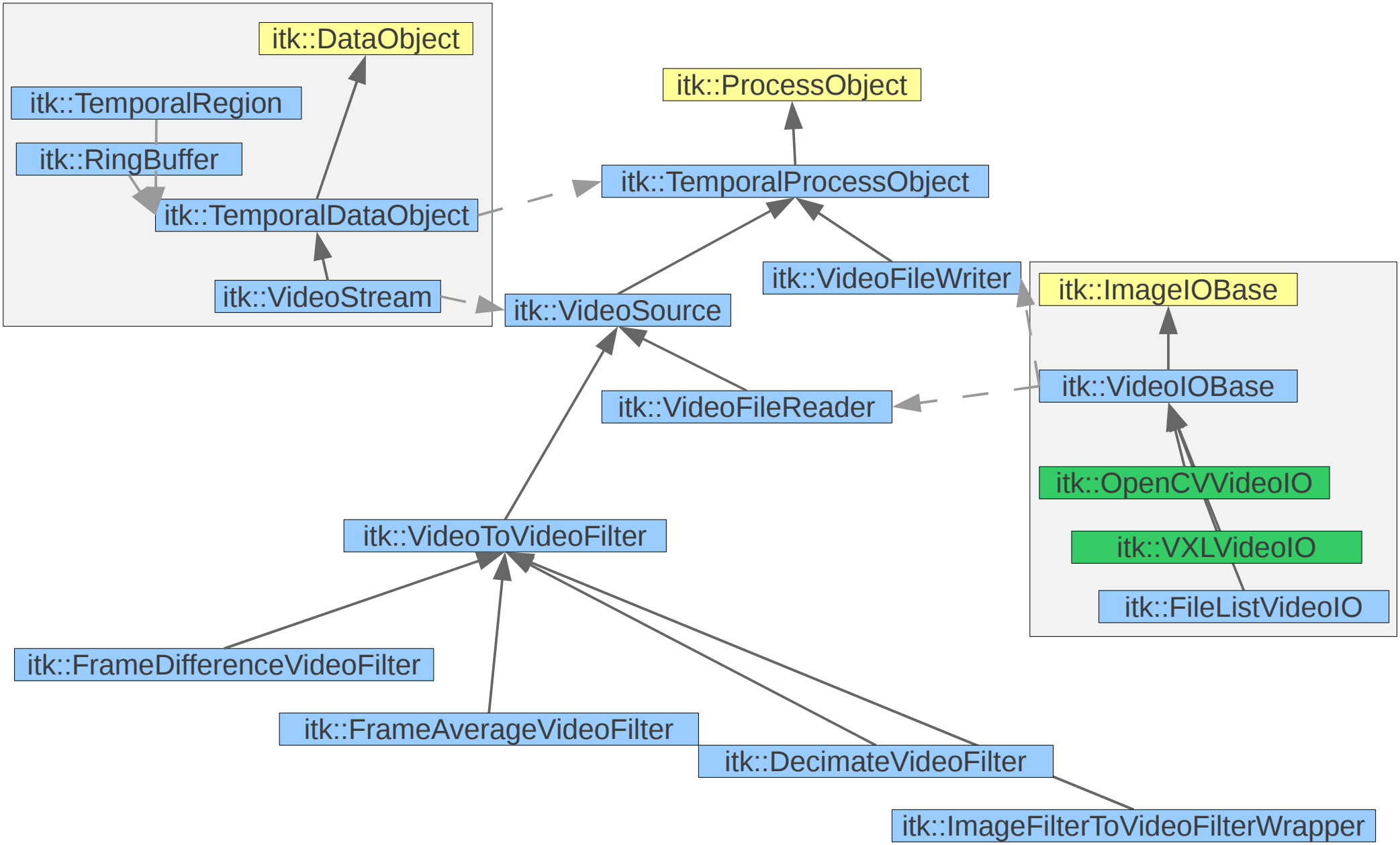
```
reader->SetFileName( argv[1] ); // video reader
writer->SetFileName( argv[2] ); // video writer
frameDifferenceFilter->SetFrameOffset(1);
videoCaster->SetImageFilter( imageCaster );
imageThresh->ThresholdBelow( 128 );
videoThresh->SetImageFilter( imageThresh );
imageCurvatureFlowFilter->SetTimeStep( 0.5 );
imageCurvatureFlowFilter->SetNumberOfIterations( 20 );
videoCurvatureFlowFilter->SetImageFilter( imageFilter );

videoCurvatureFlowFilter->SetInput( reader->GetOutput() );
videoCaster->SetInput( videoFilter->GetOutput() );
frameDifferenceFilter->SetInput( videoCaster->GetOutput() );
videoThresh->SetInput( frameDifferenceFilter->GetOutput() );
writer->SetInput( videoThresh->GetOutput() );

writer->Update(); // generate output video frame by frame, without reading whole source video at once
```

New Classes

New classes

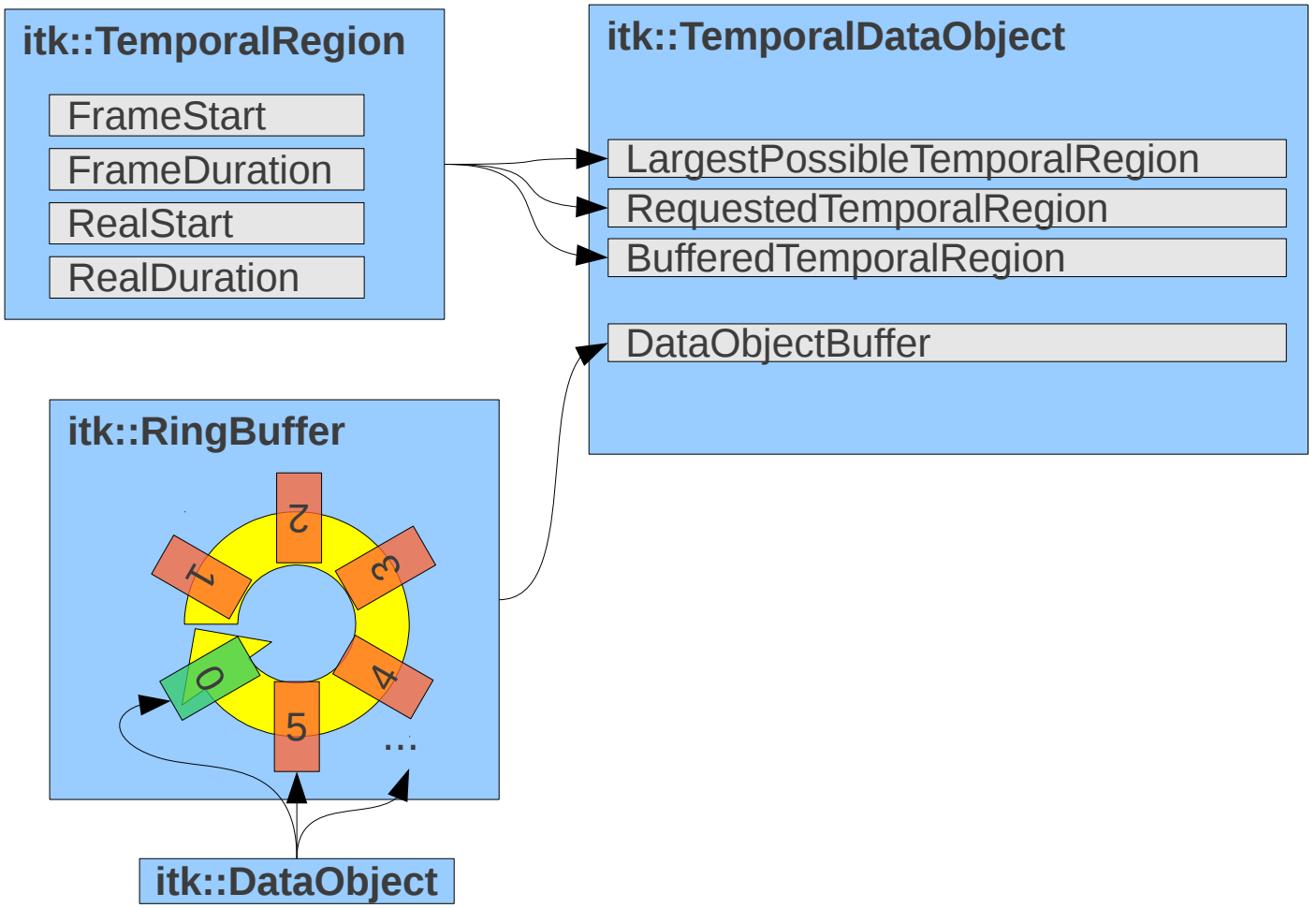
- Real-time capture:
  - A new video I/O classes wrapping a capture library
- Course:
  - ITK video filters
  - ITK representations of non-pixel data (tracks, etc.)

Class Hierarchy

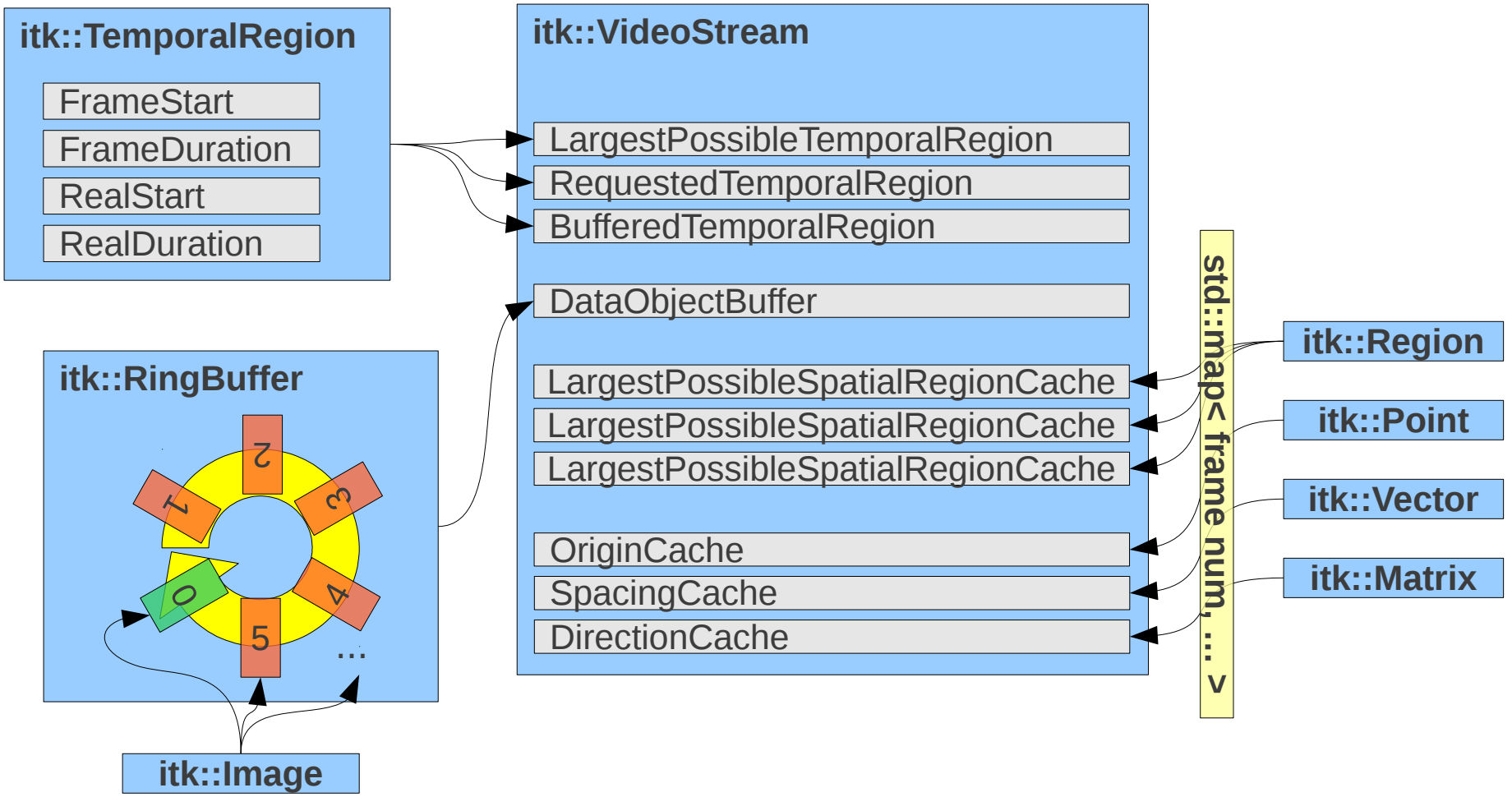


Temporal Data Objects

itk::TemporalDataObject

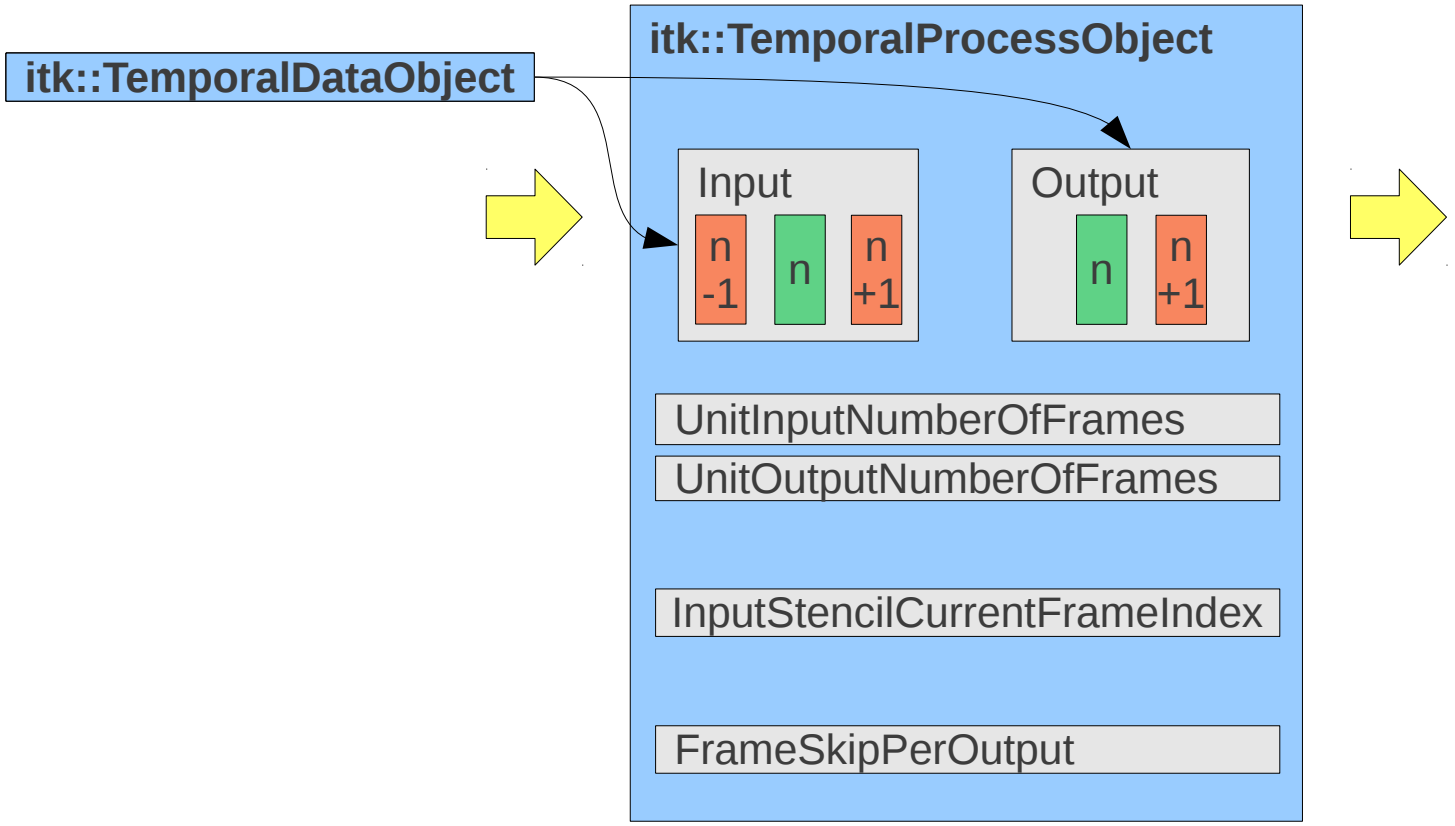


itk::VideoStream

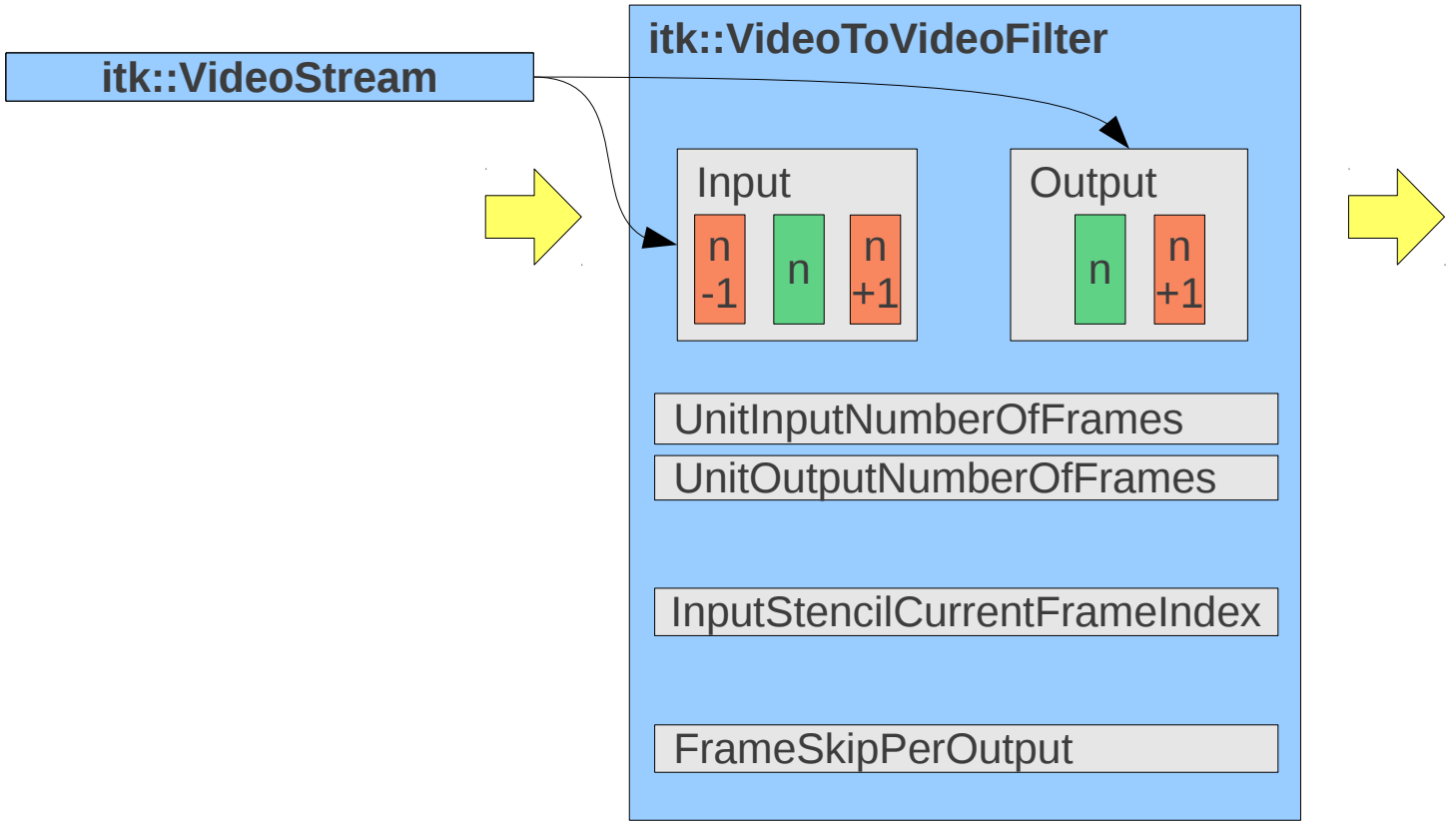


Temporal Process Objects

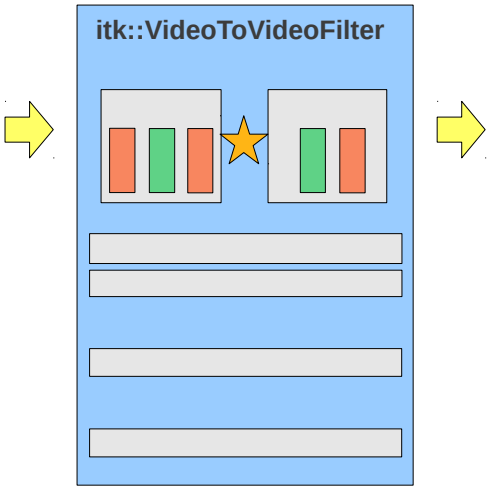
itk::TemporalProcessObject



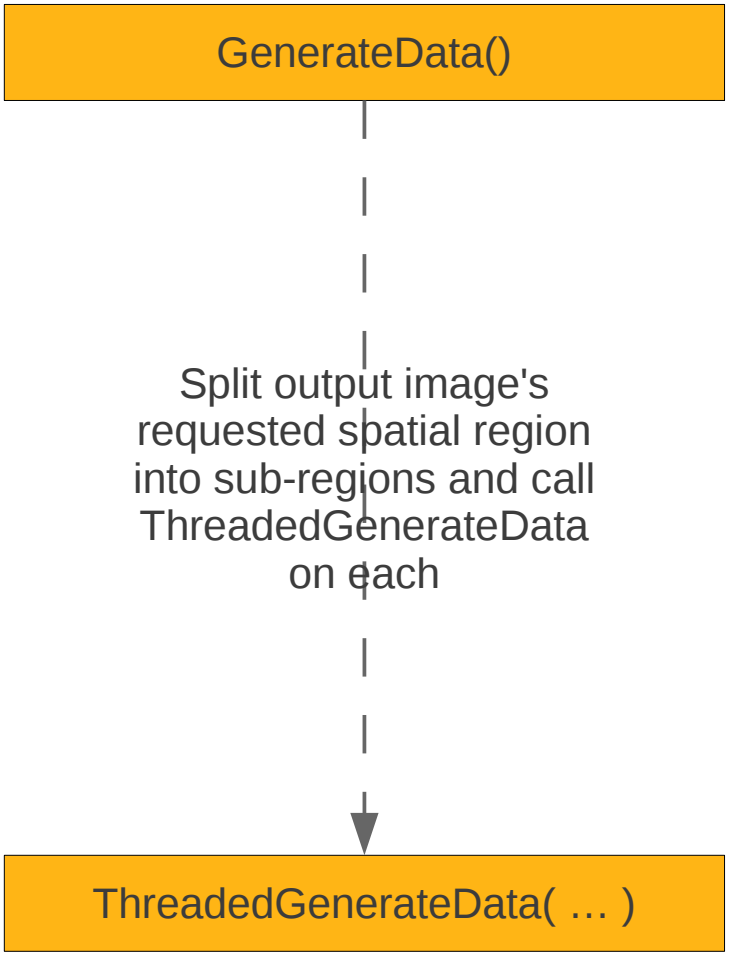
itk::VideoToVideoFilter



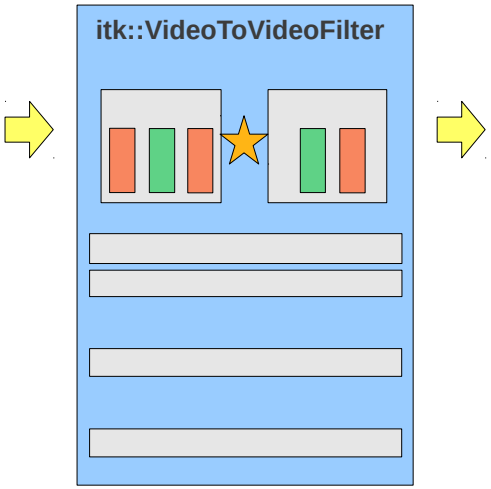
itk::ImageToImageFilter



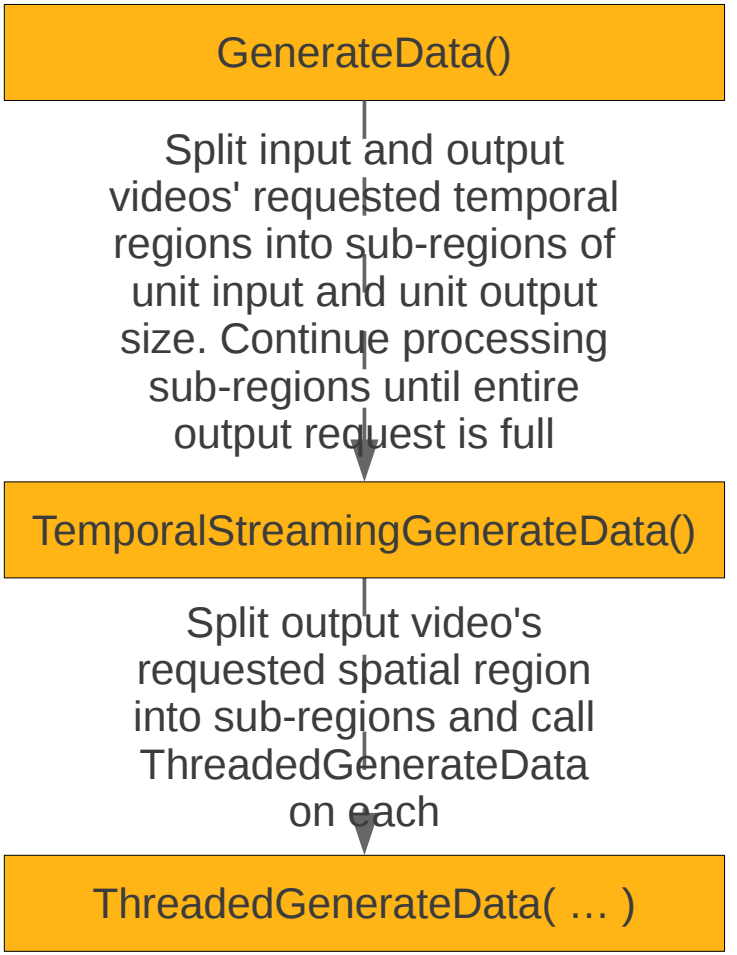
itk::ImageToImageFilter → **GenerateData** Process



itk::VideoToVideoFilter



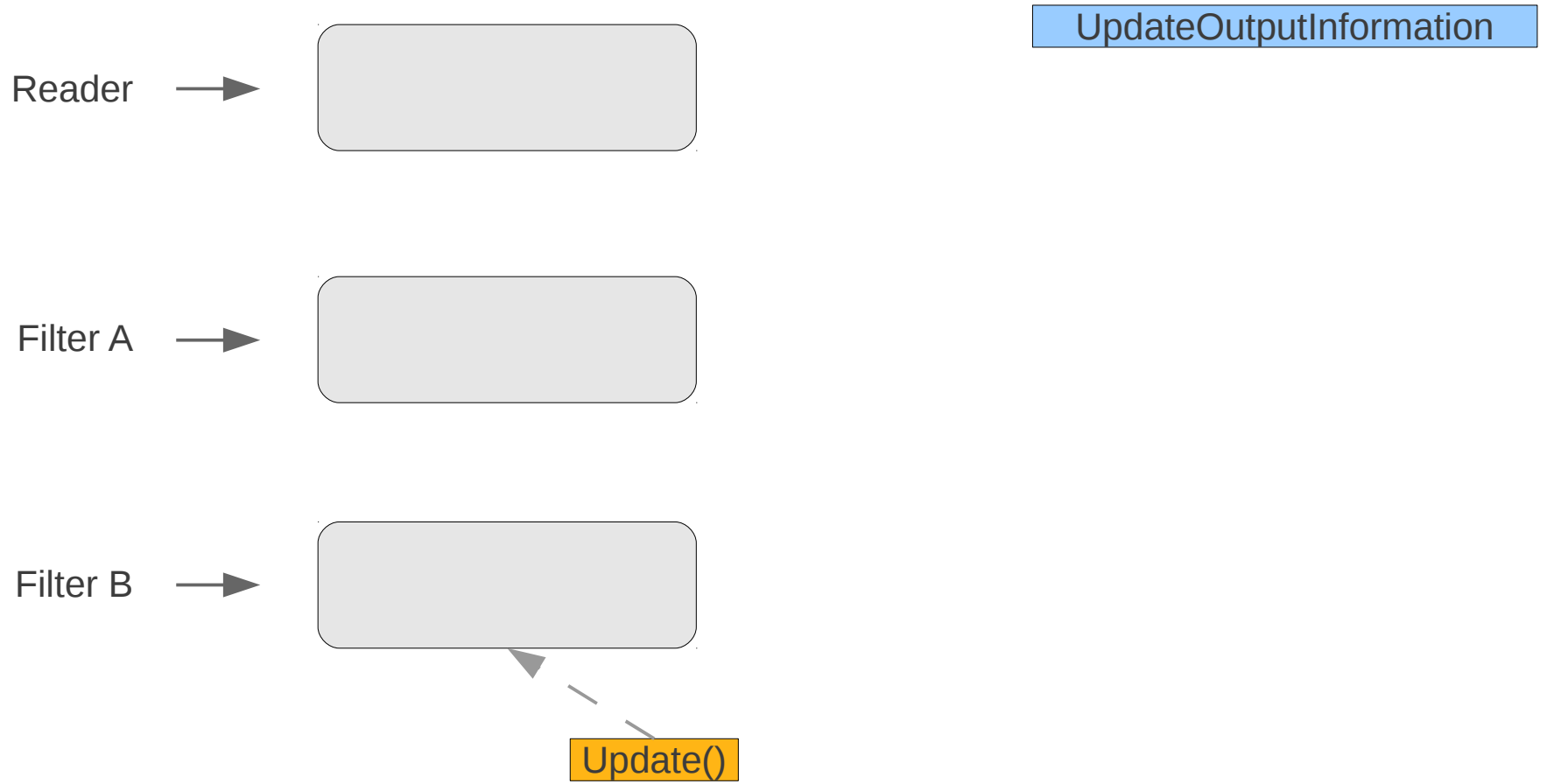
itk::VideoToVideoFilter → **GenerateData** Process



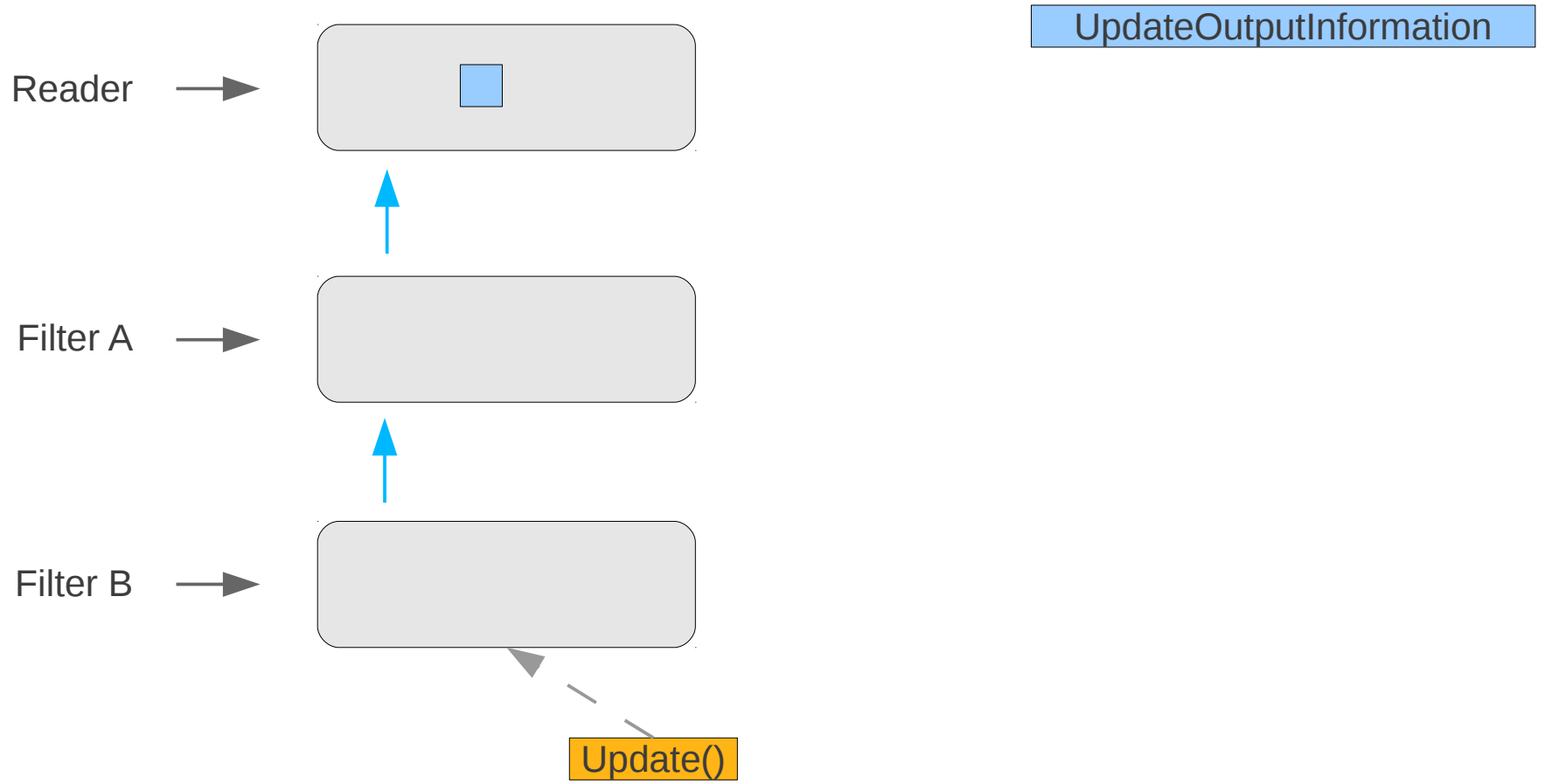
Pipeline Architecture

ITK Pipeline

ITK Pipeline



ITK Pipeline



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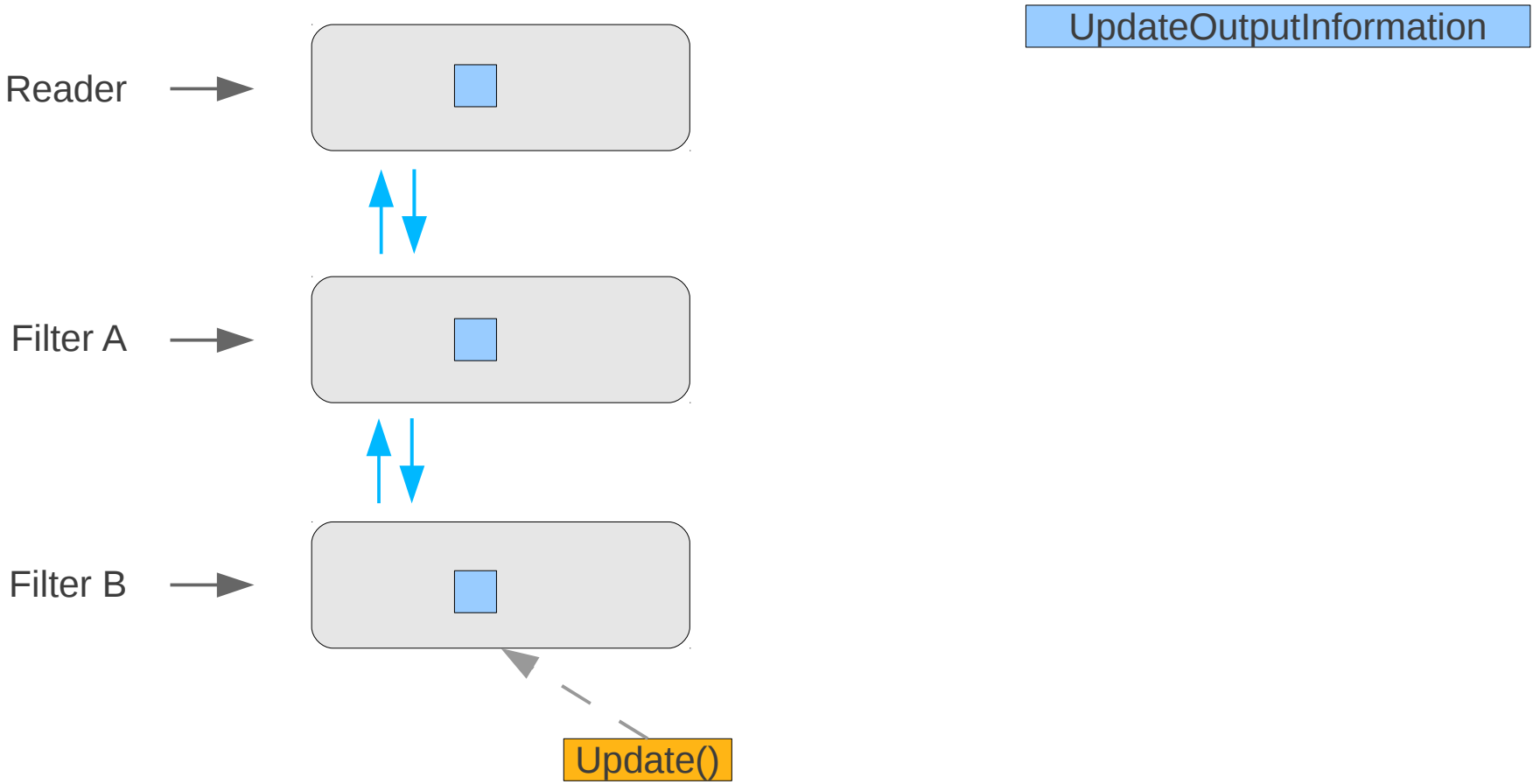

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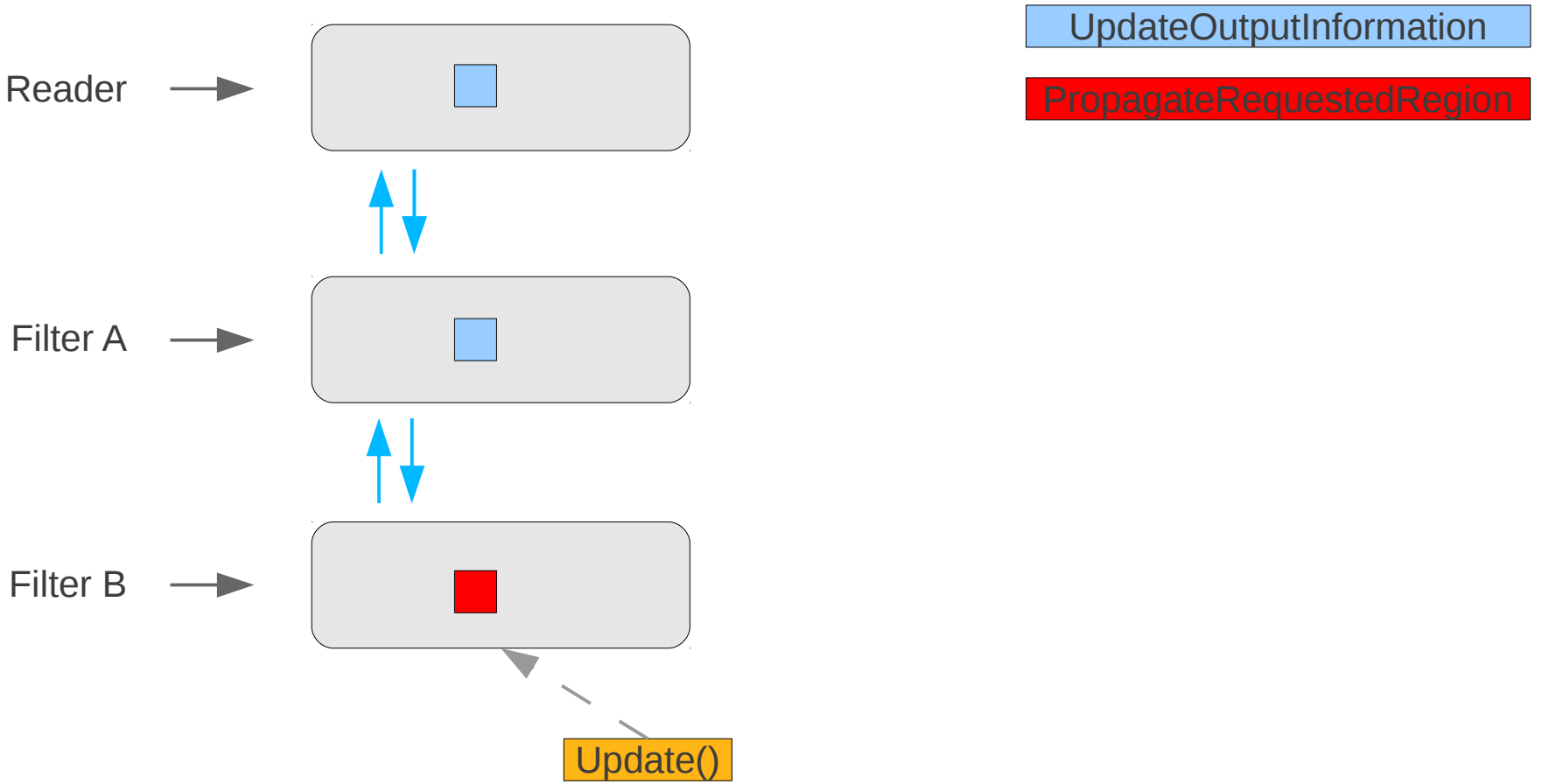

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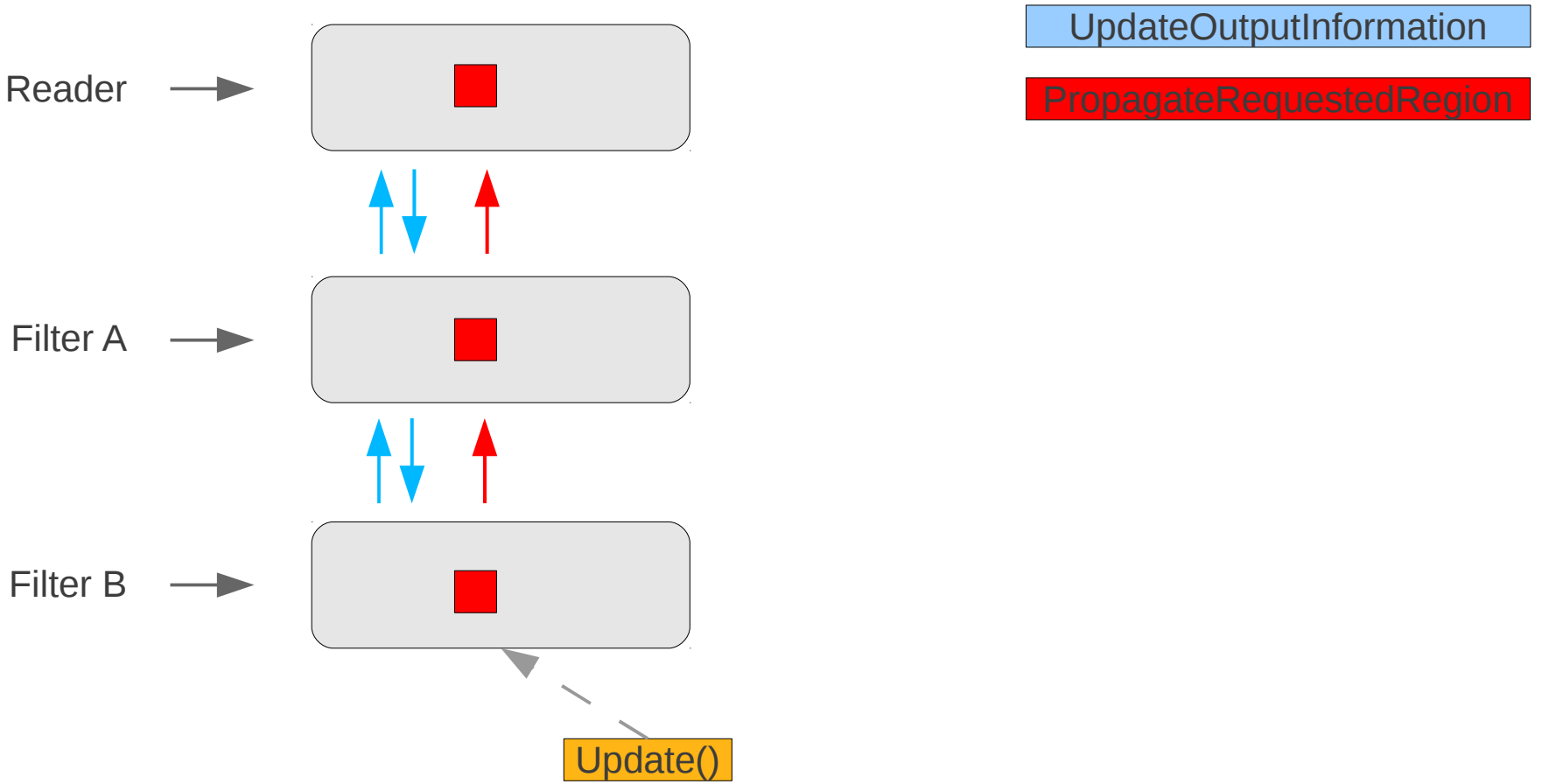

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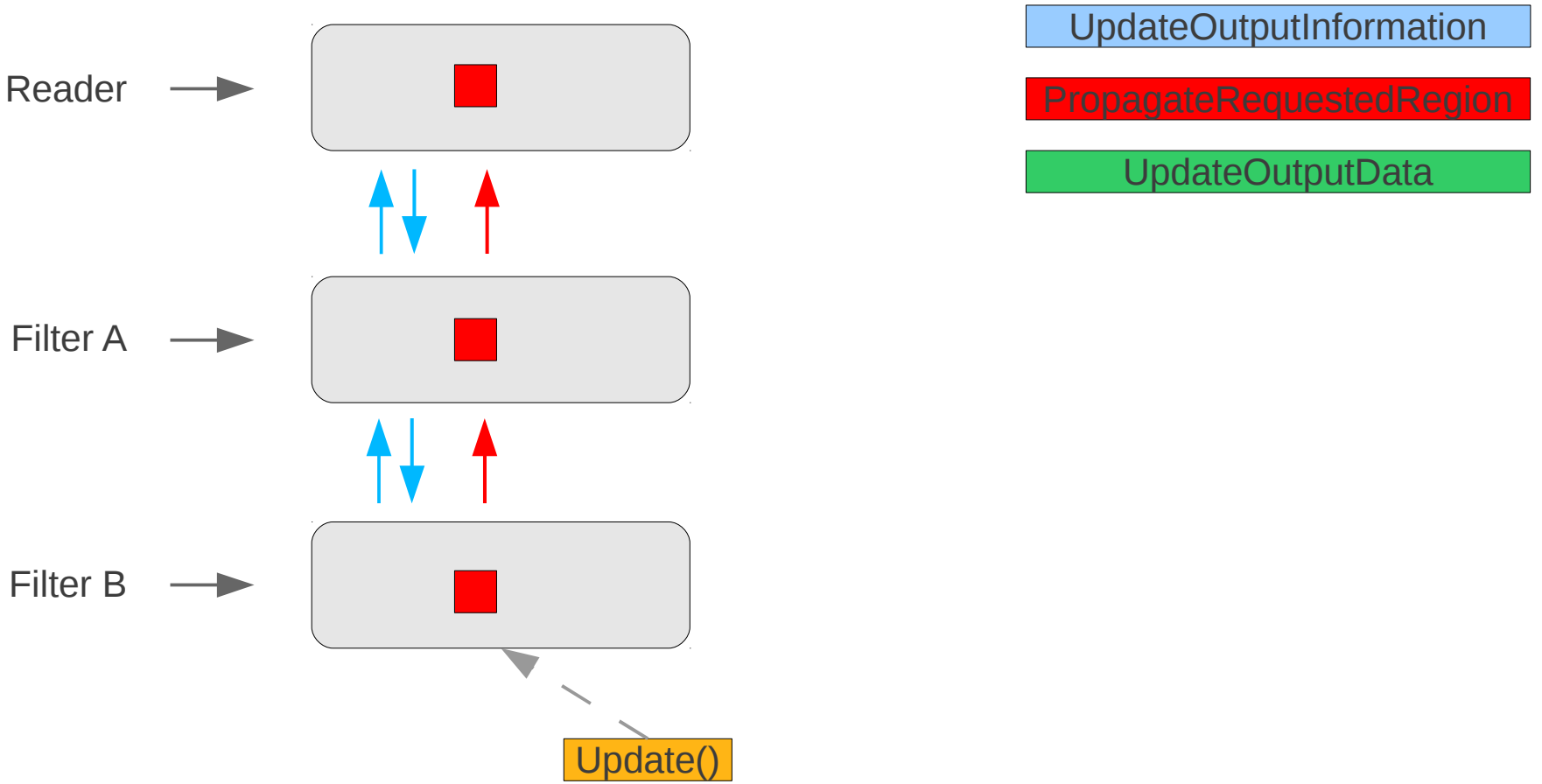

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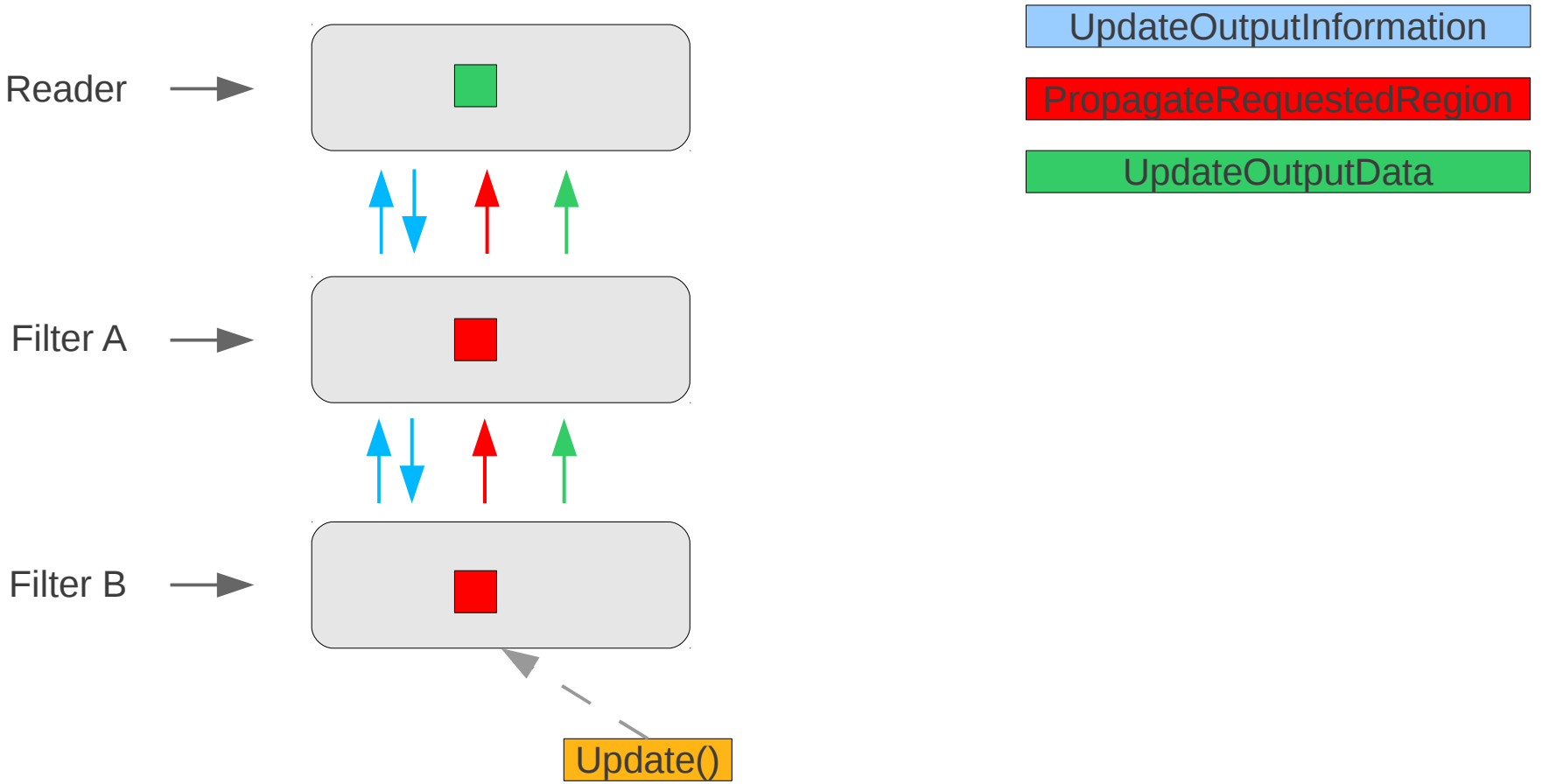

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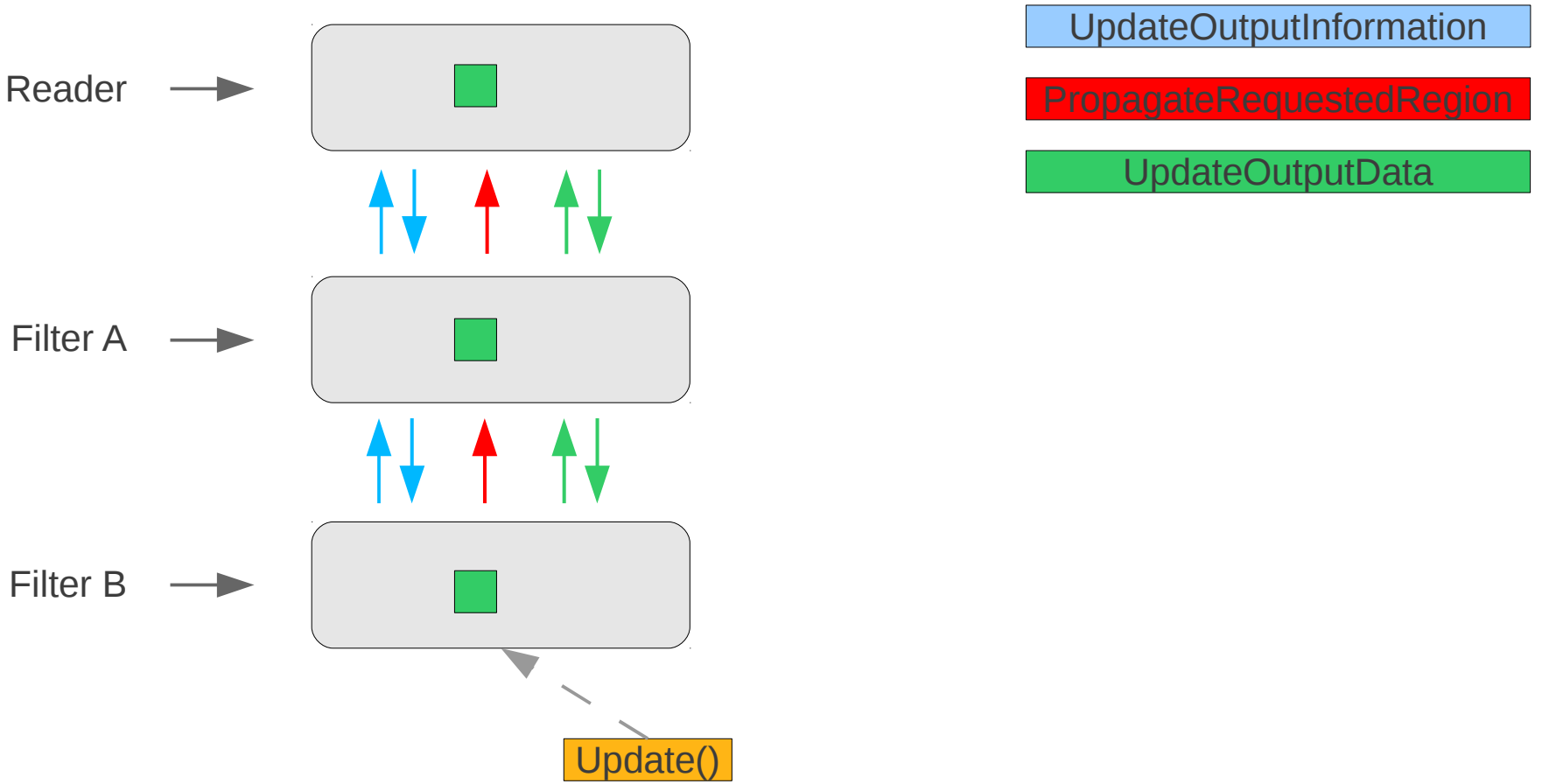

ITK Video Pipeline

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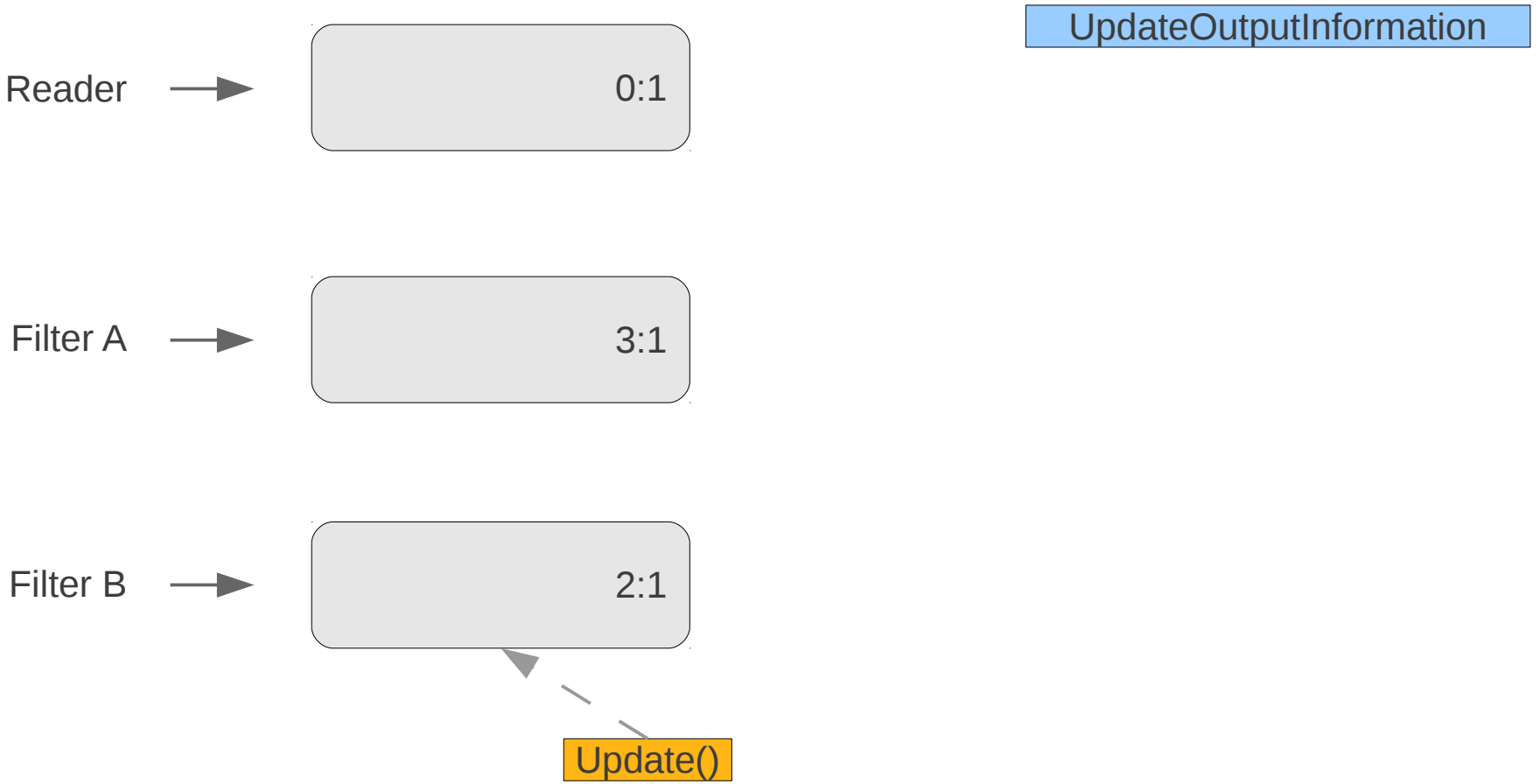

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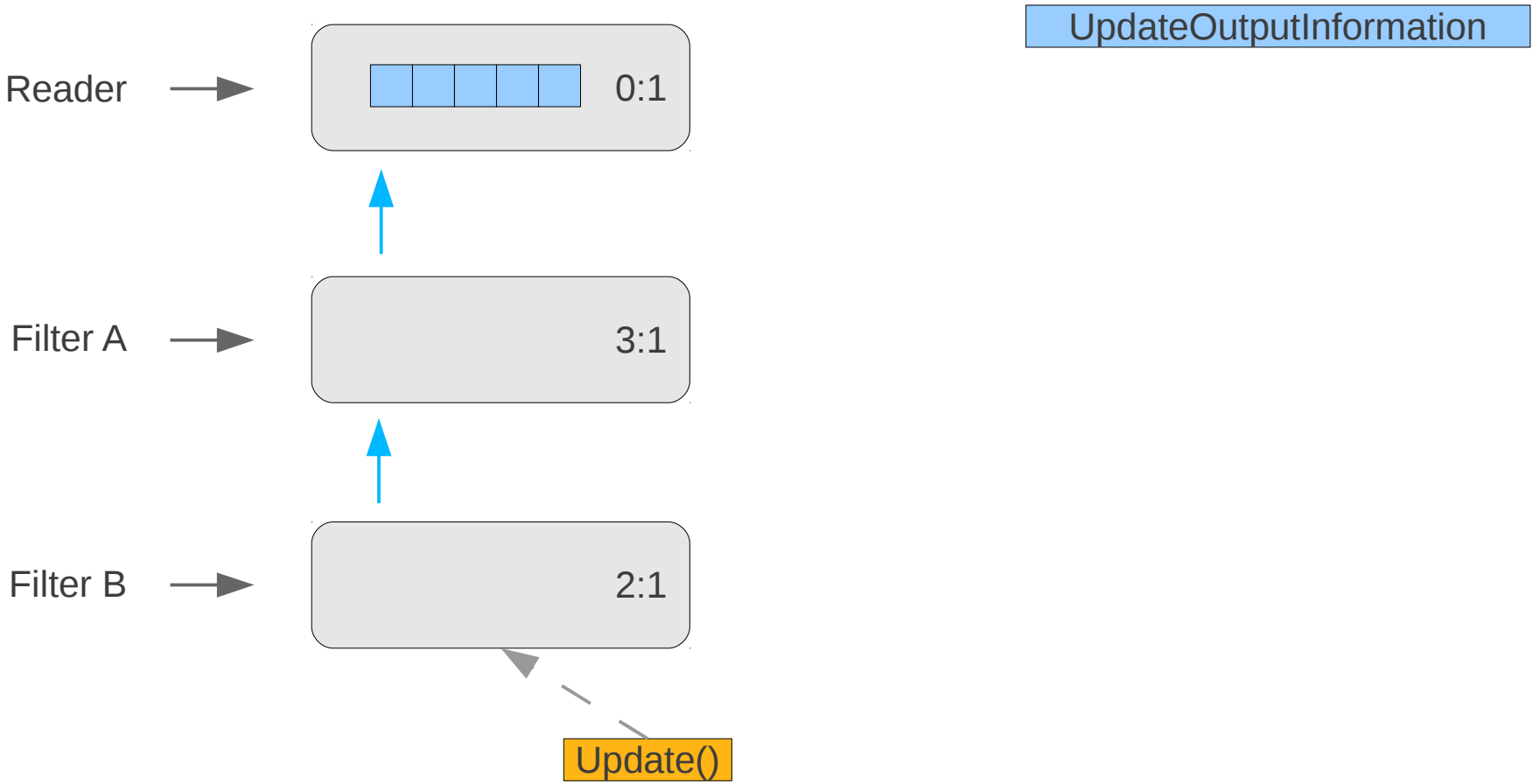

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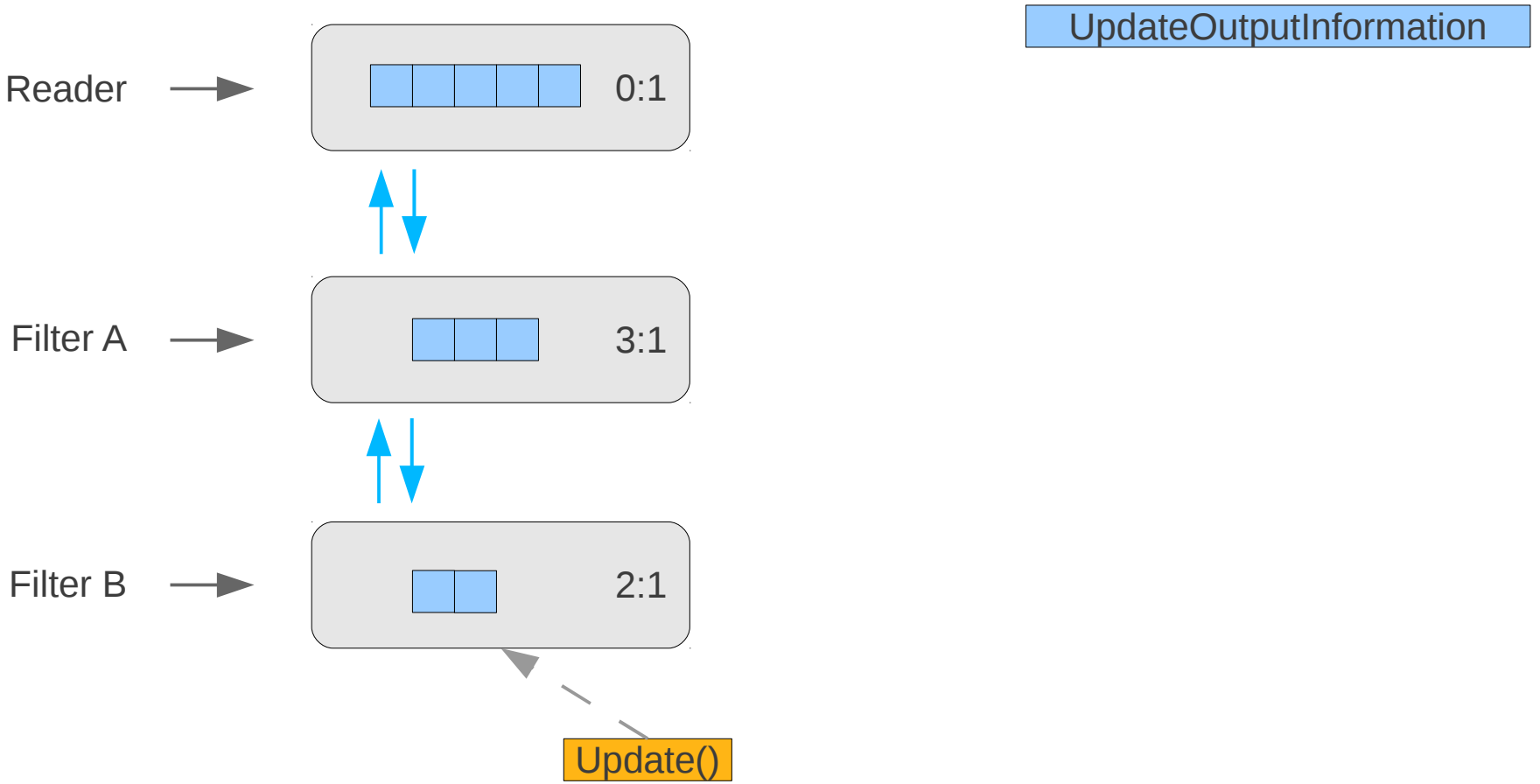

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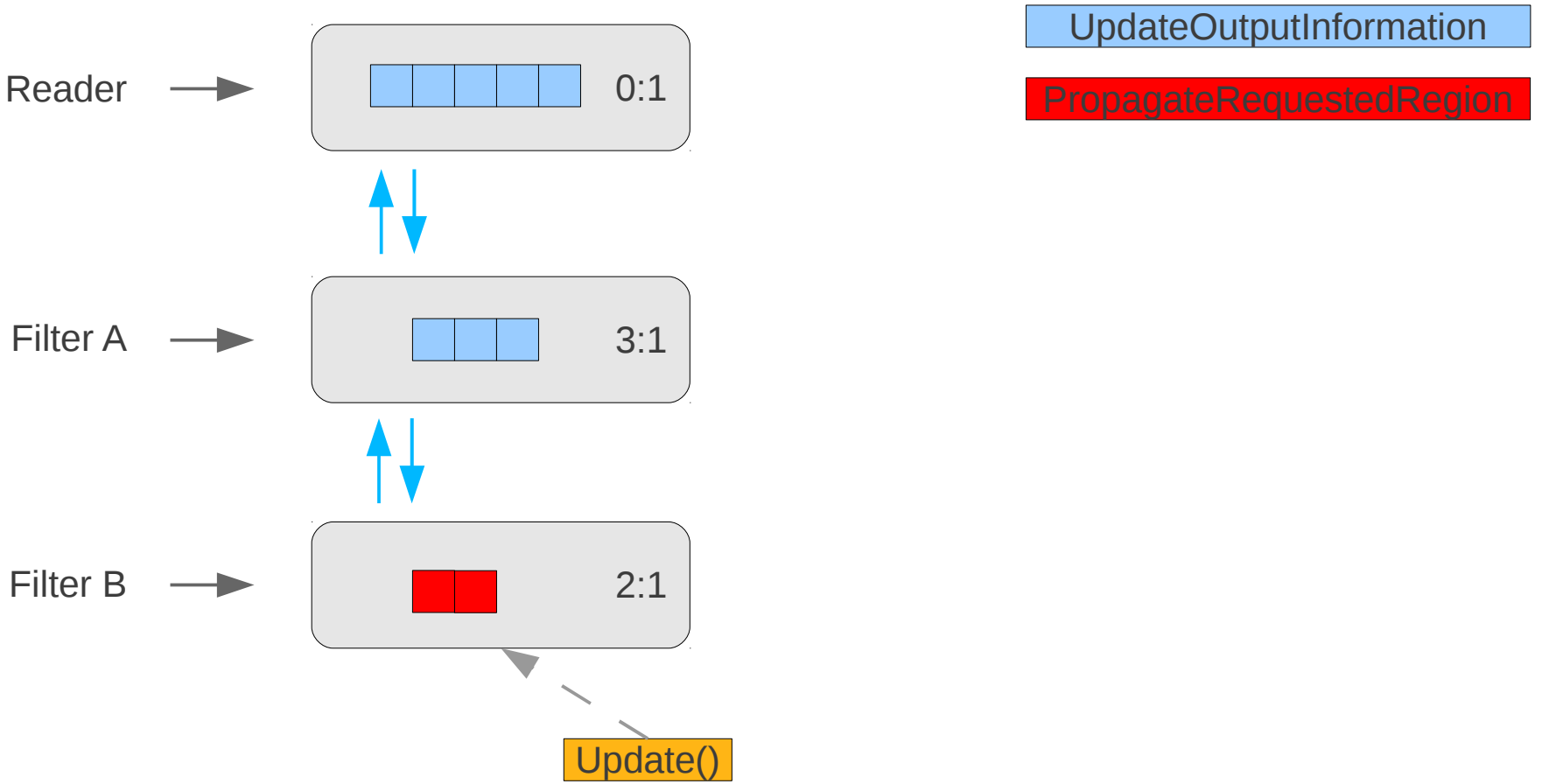

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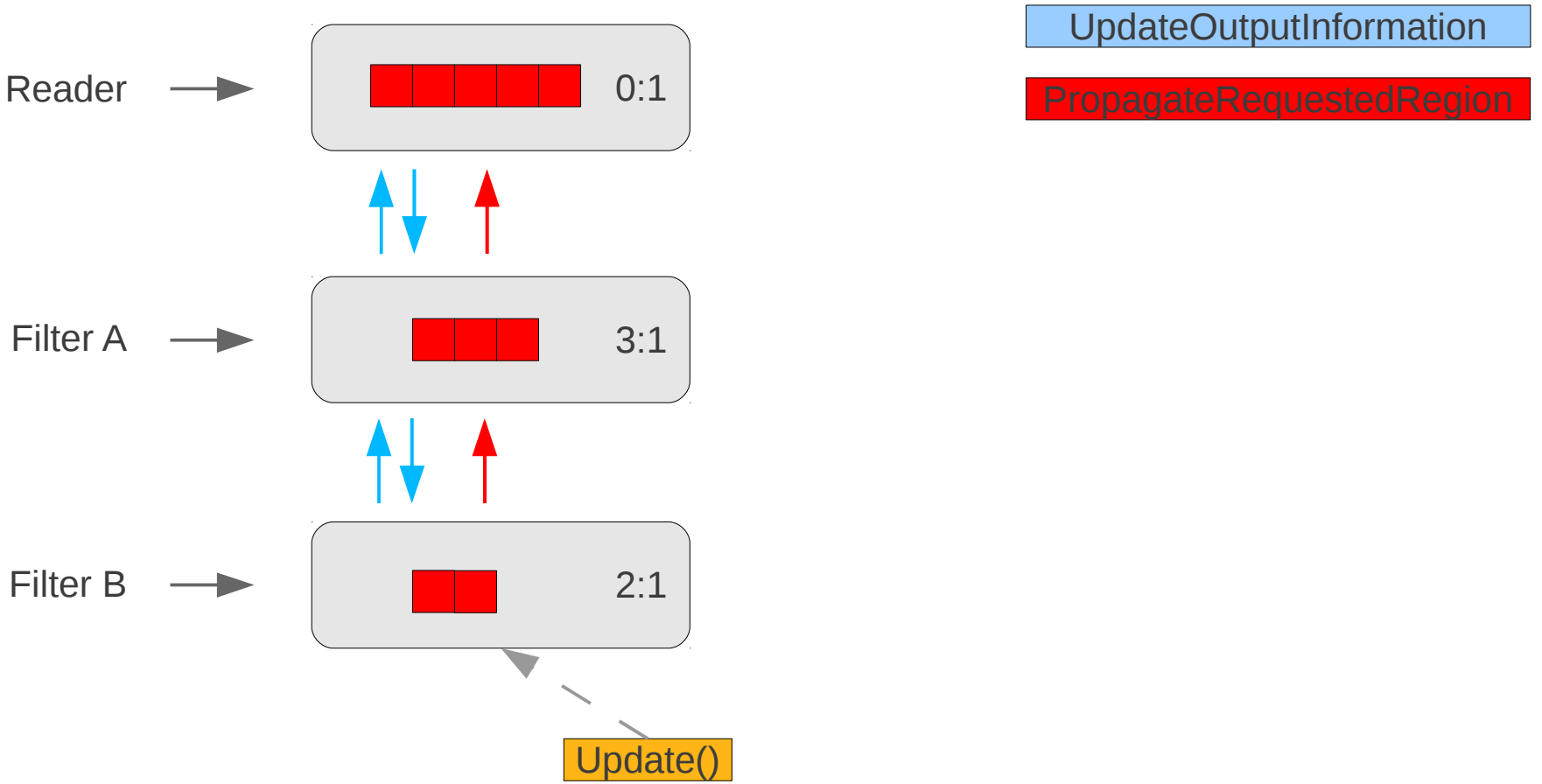

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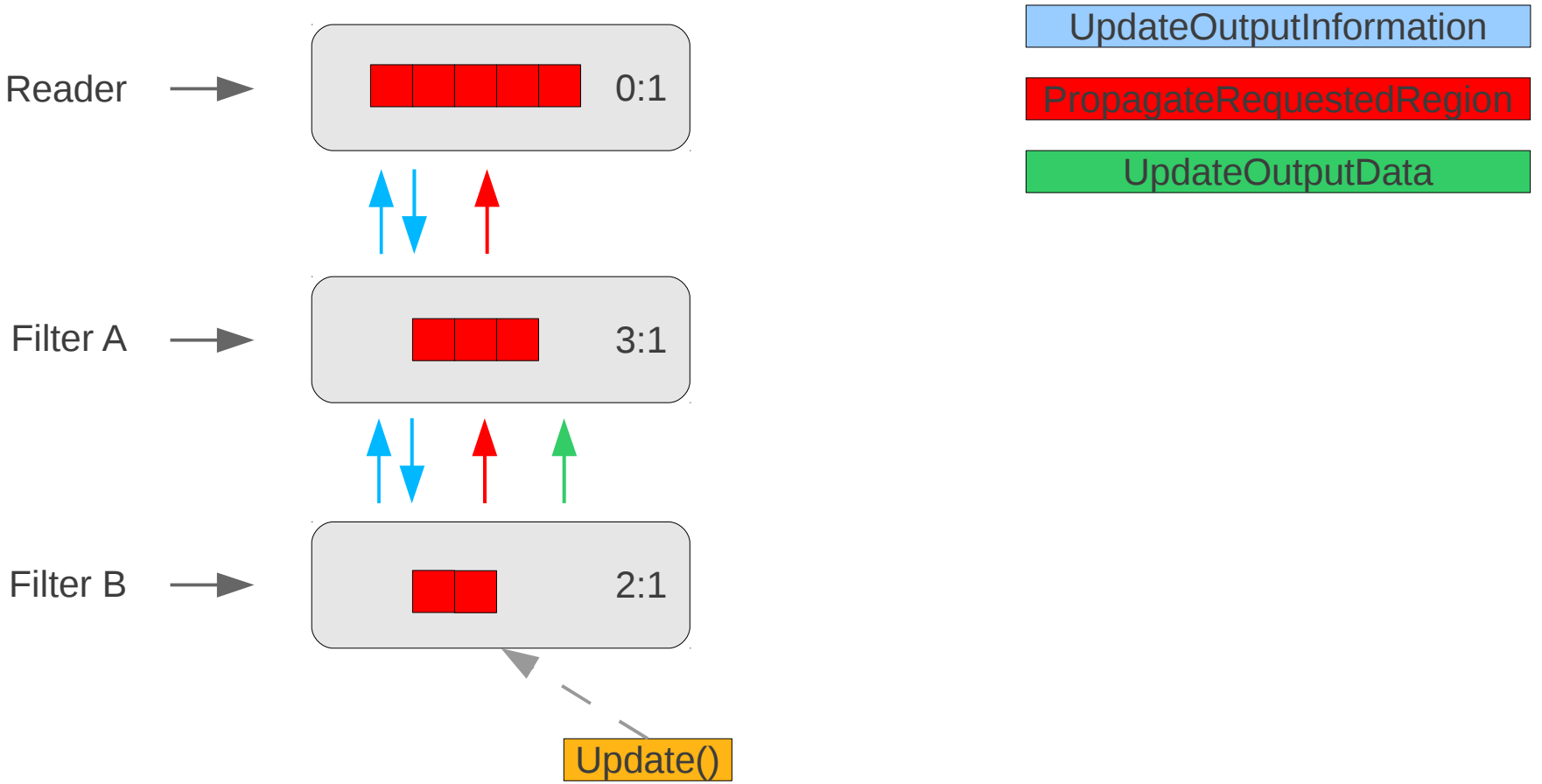

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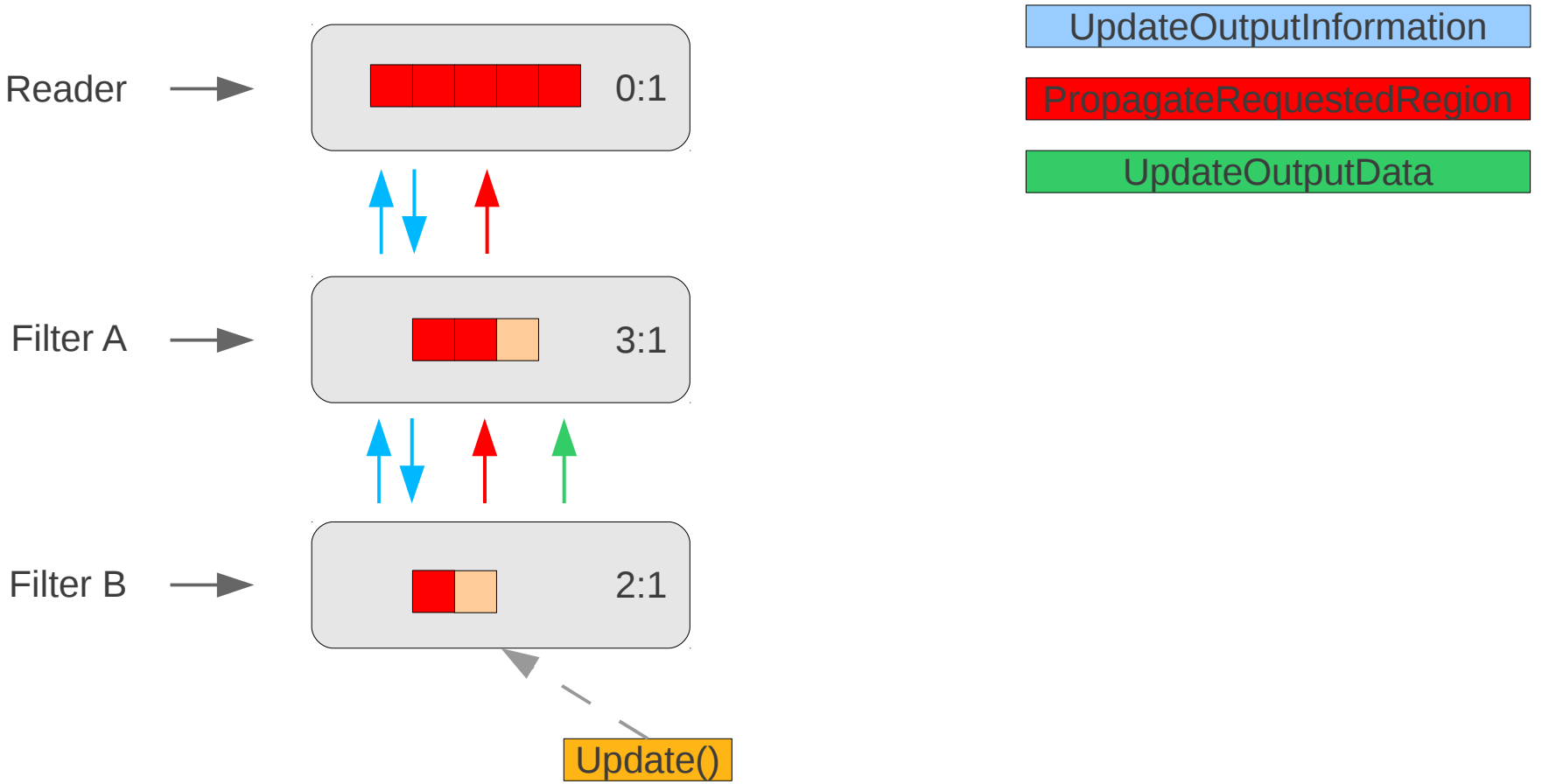

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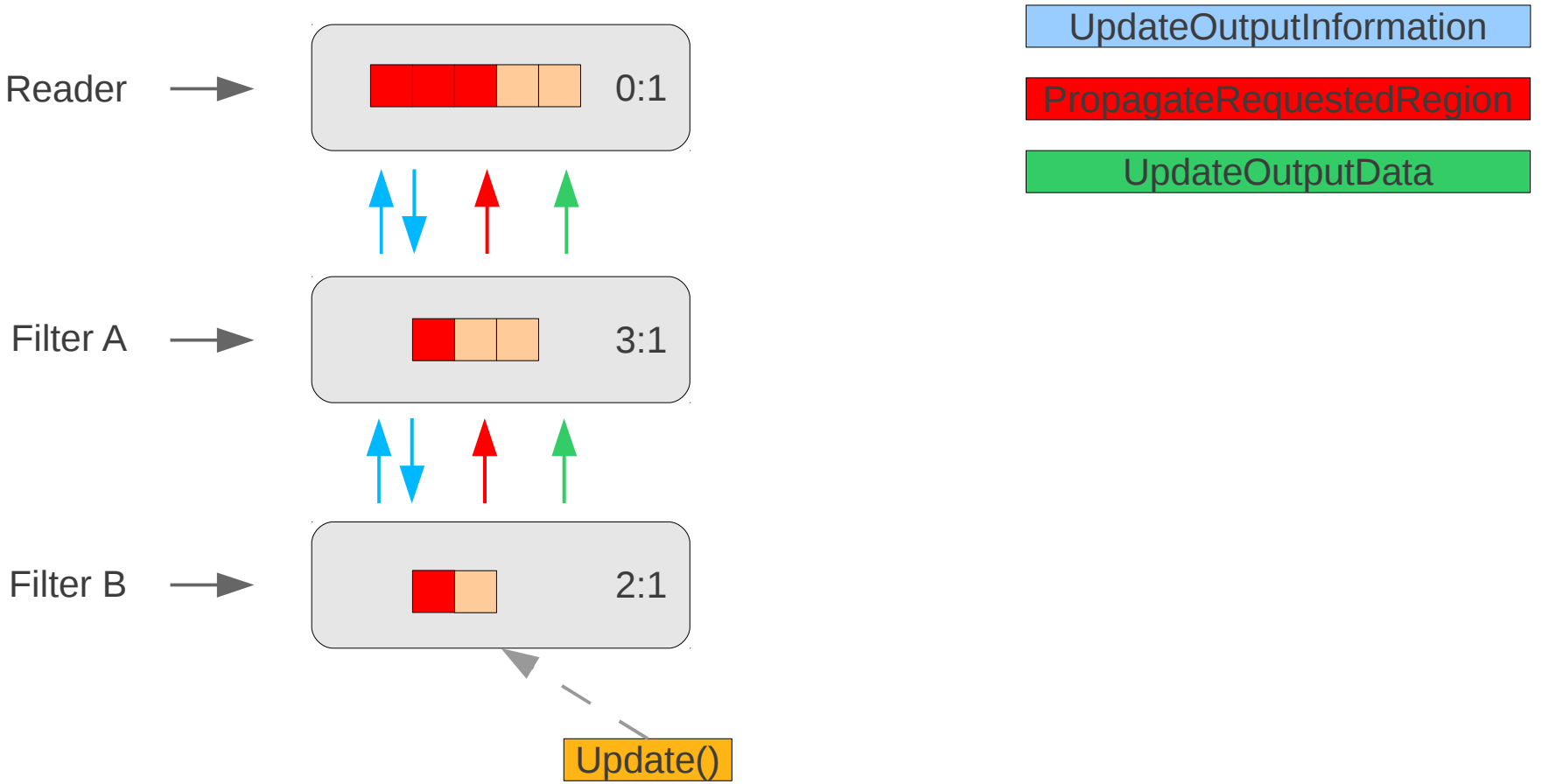

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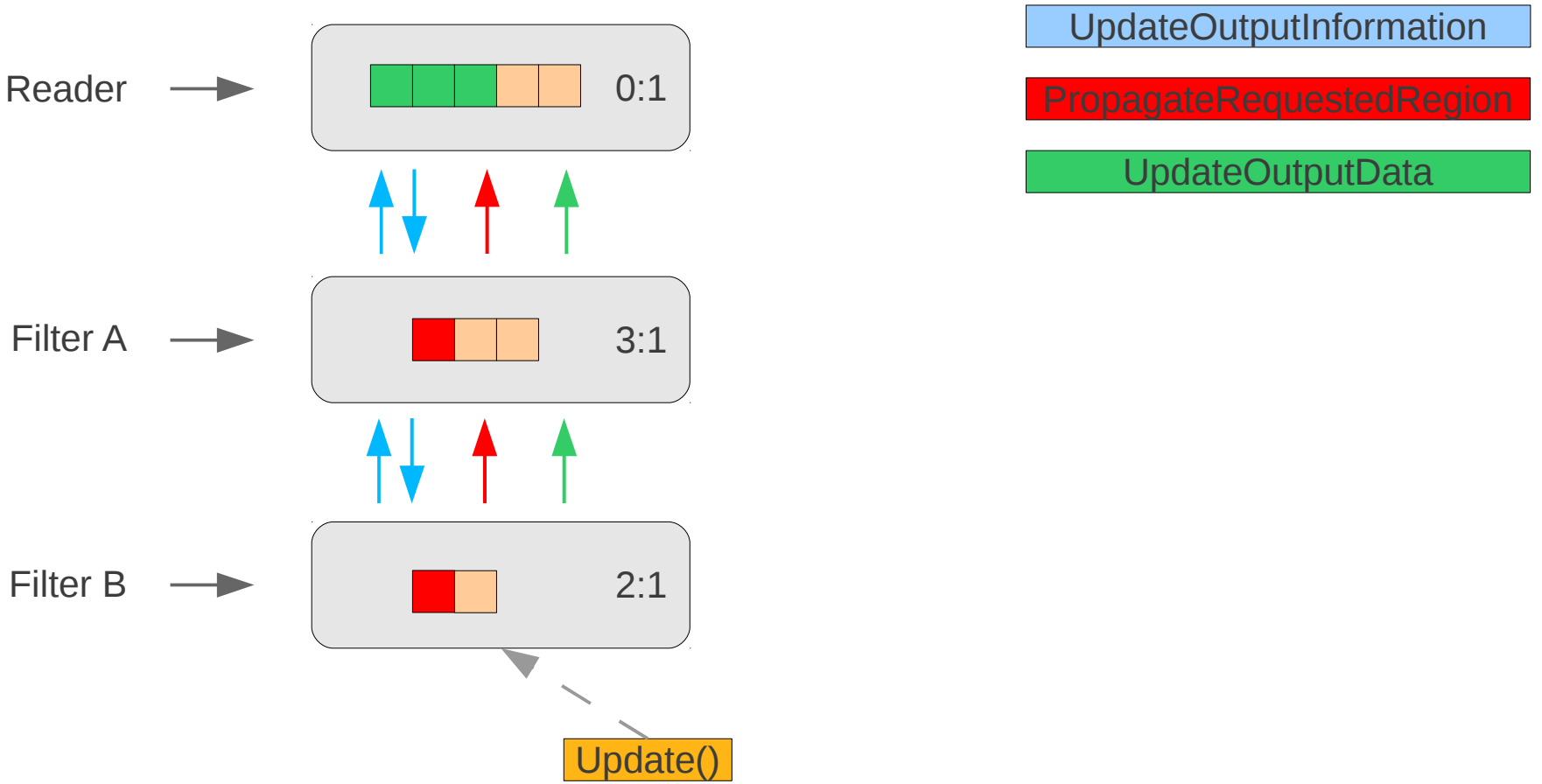

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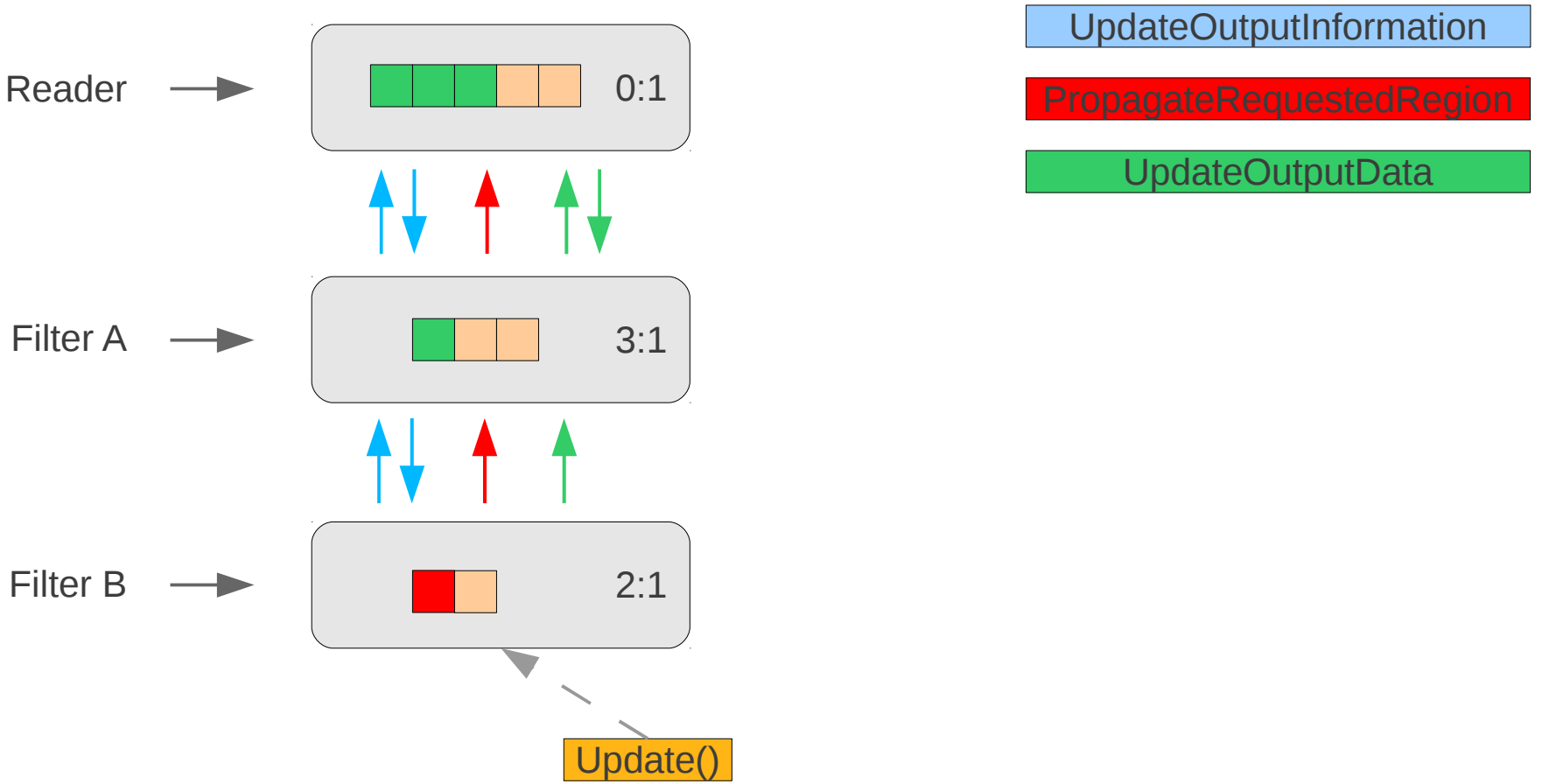

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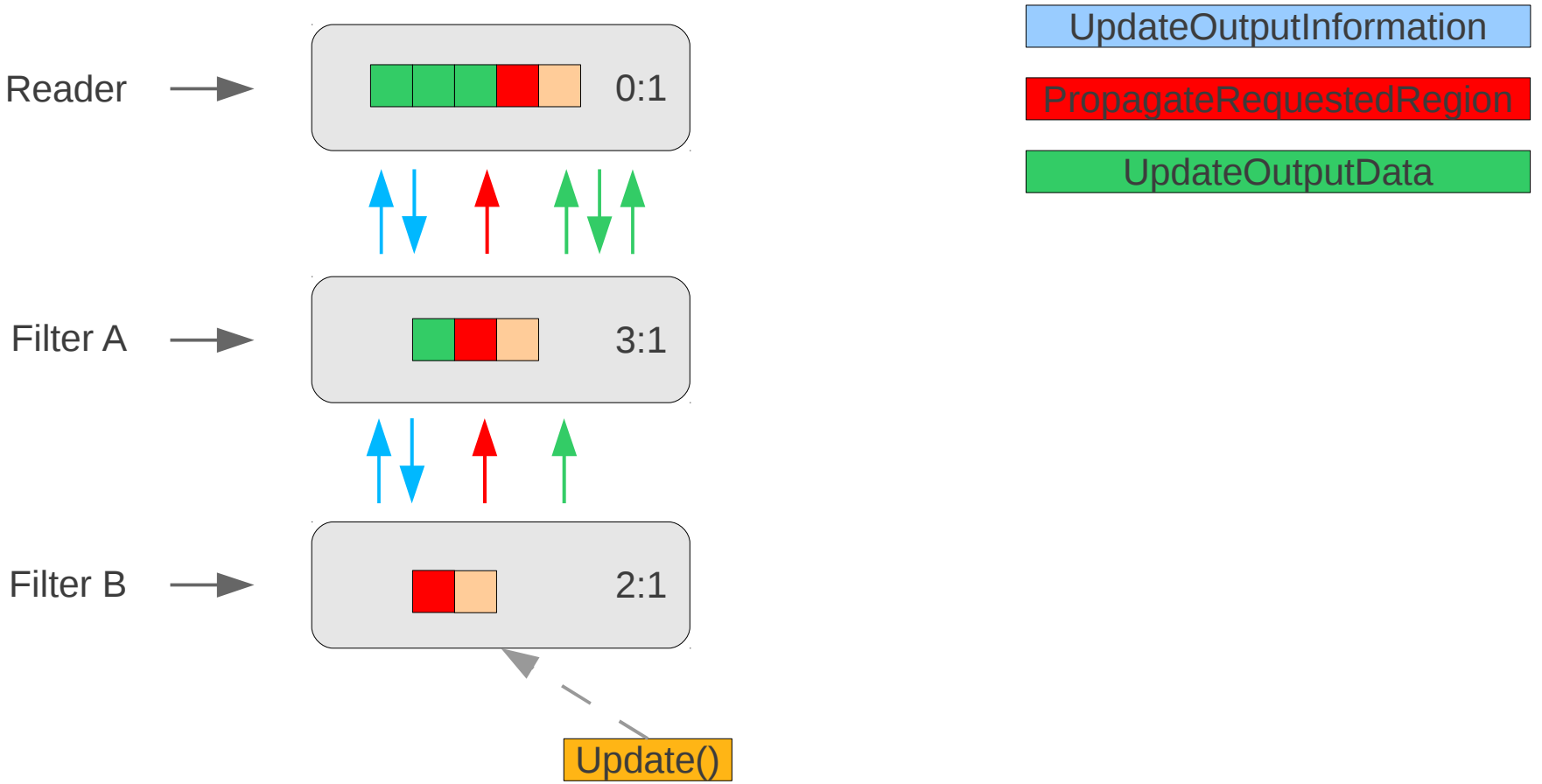

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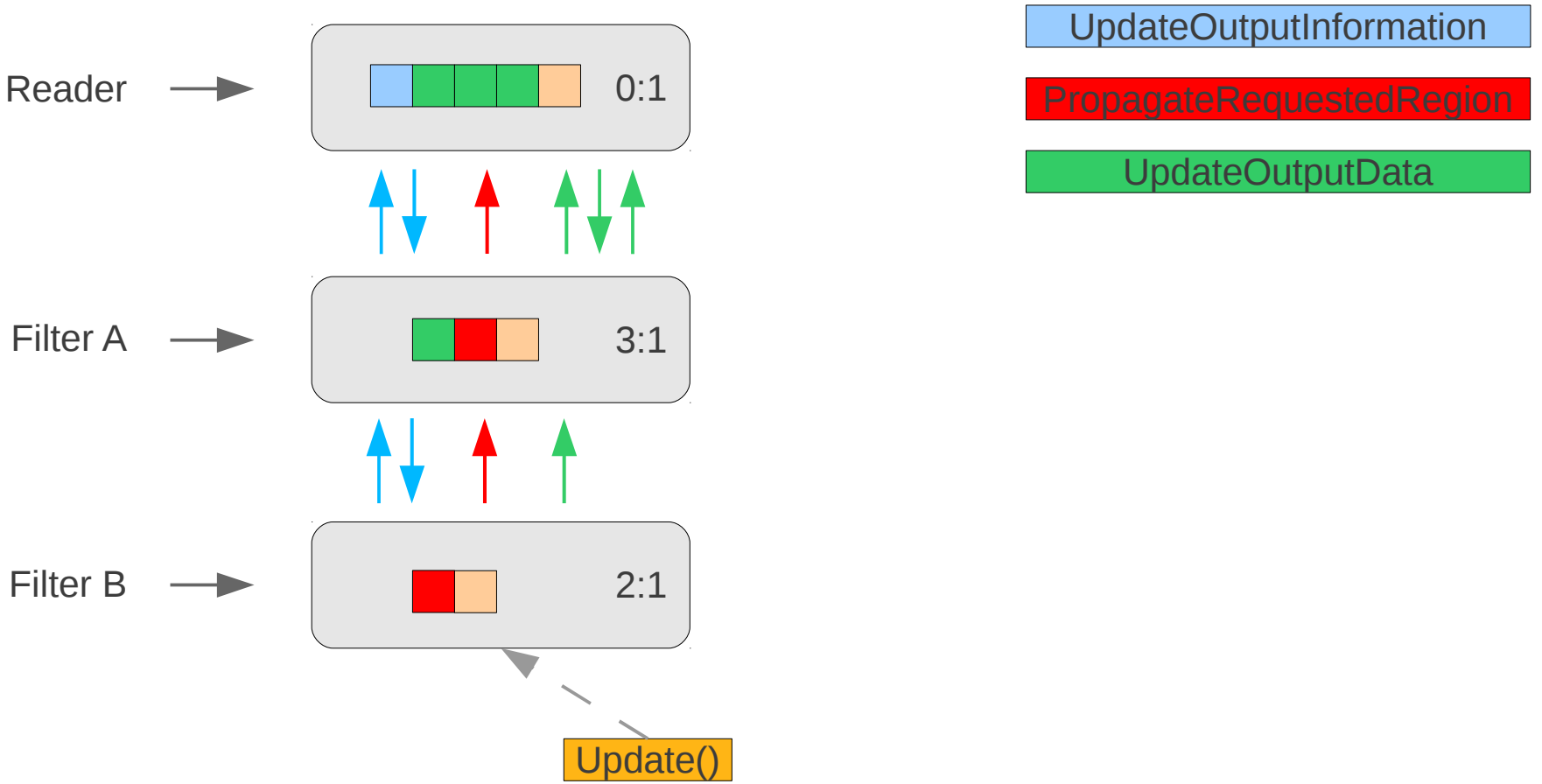

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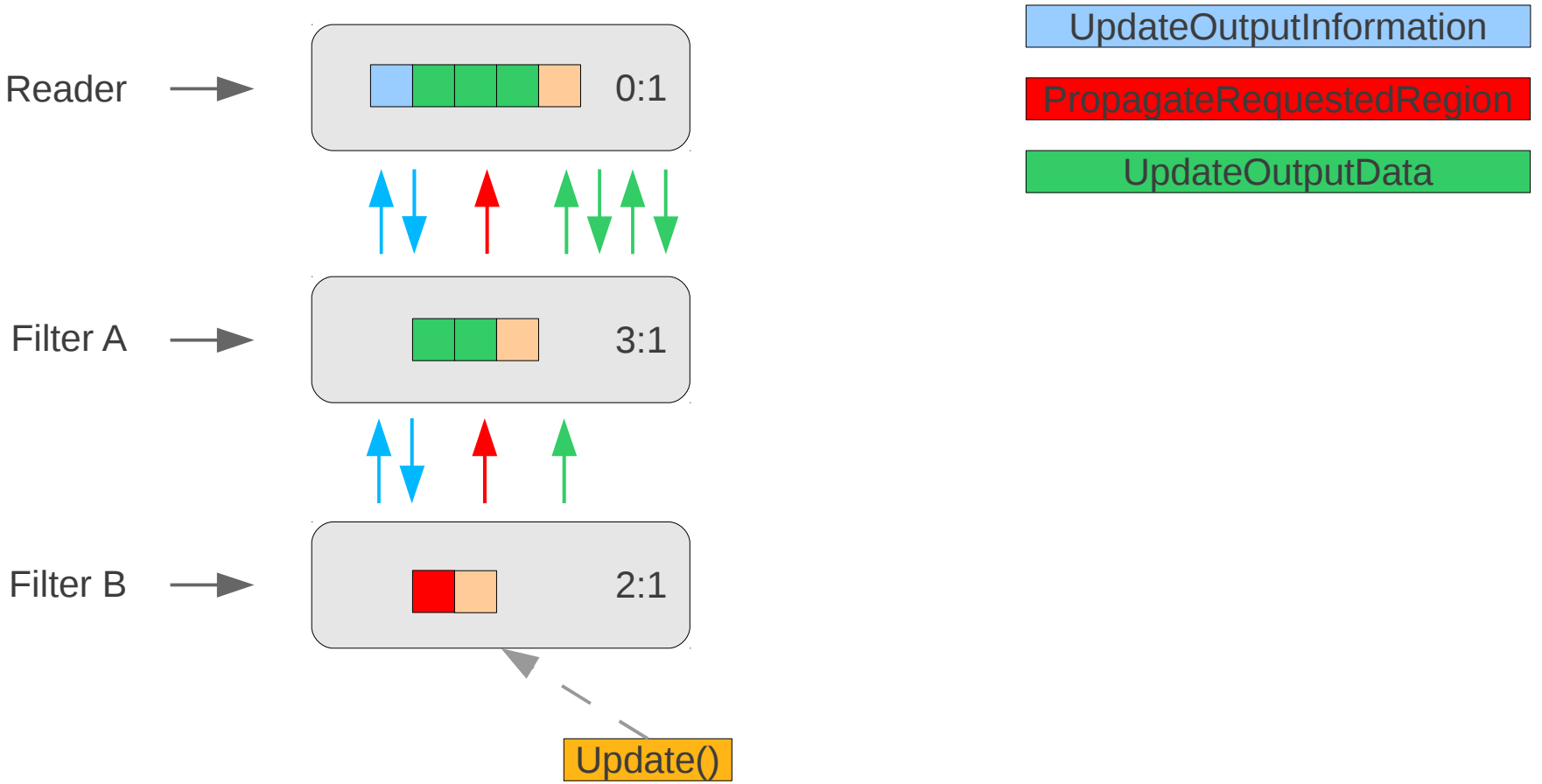

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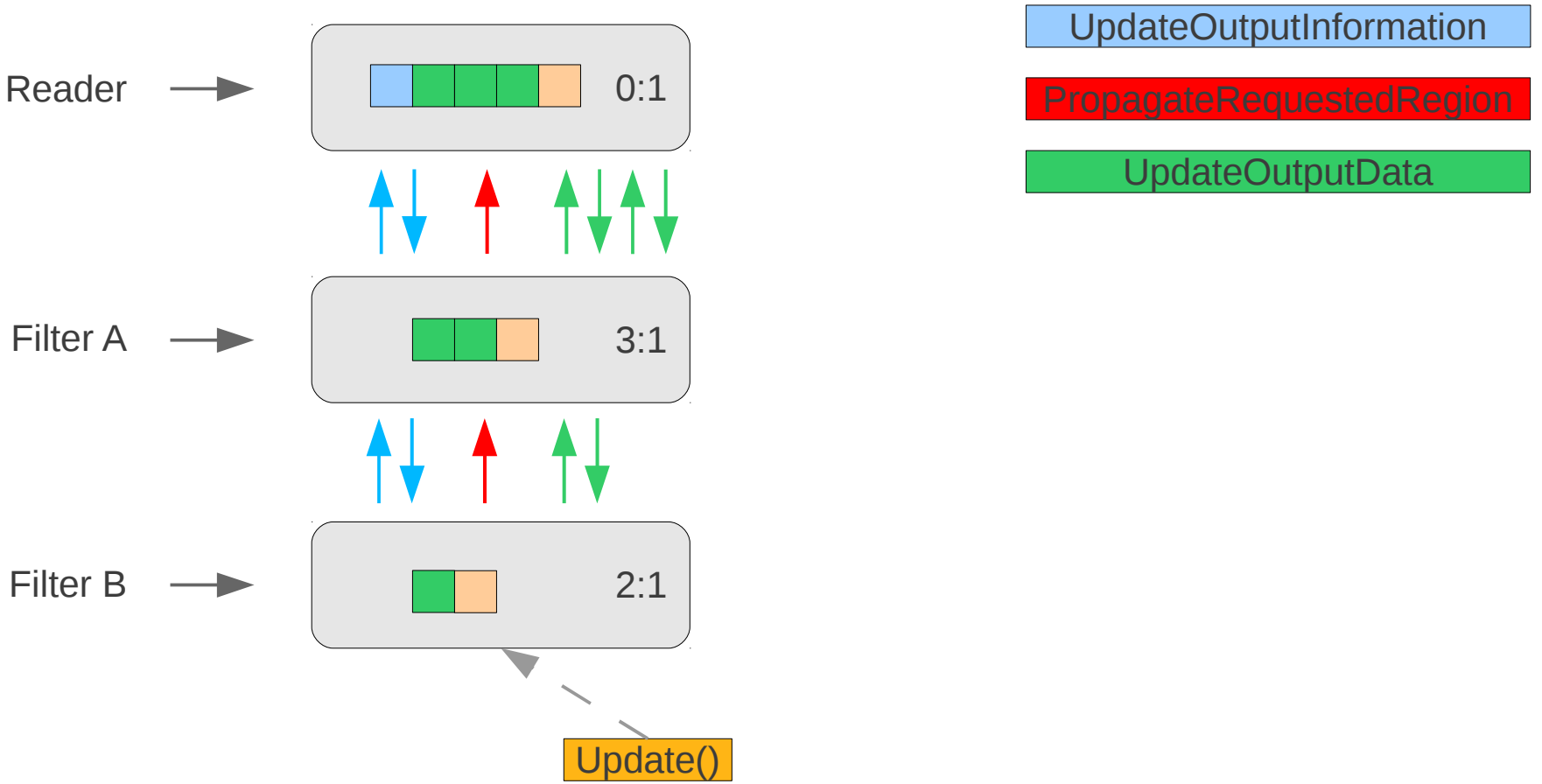

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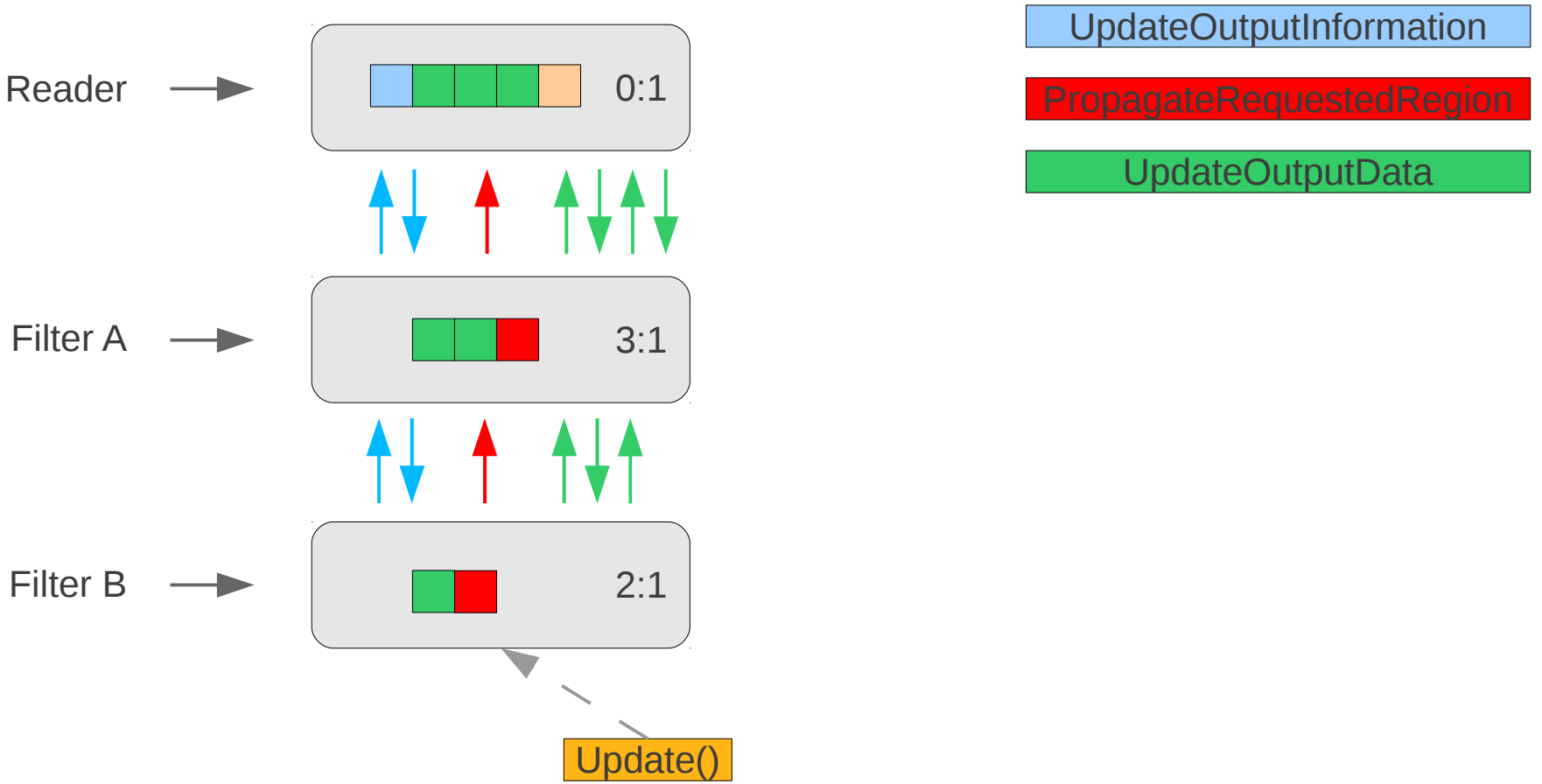

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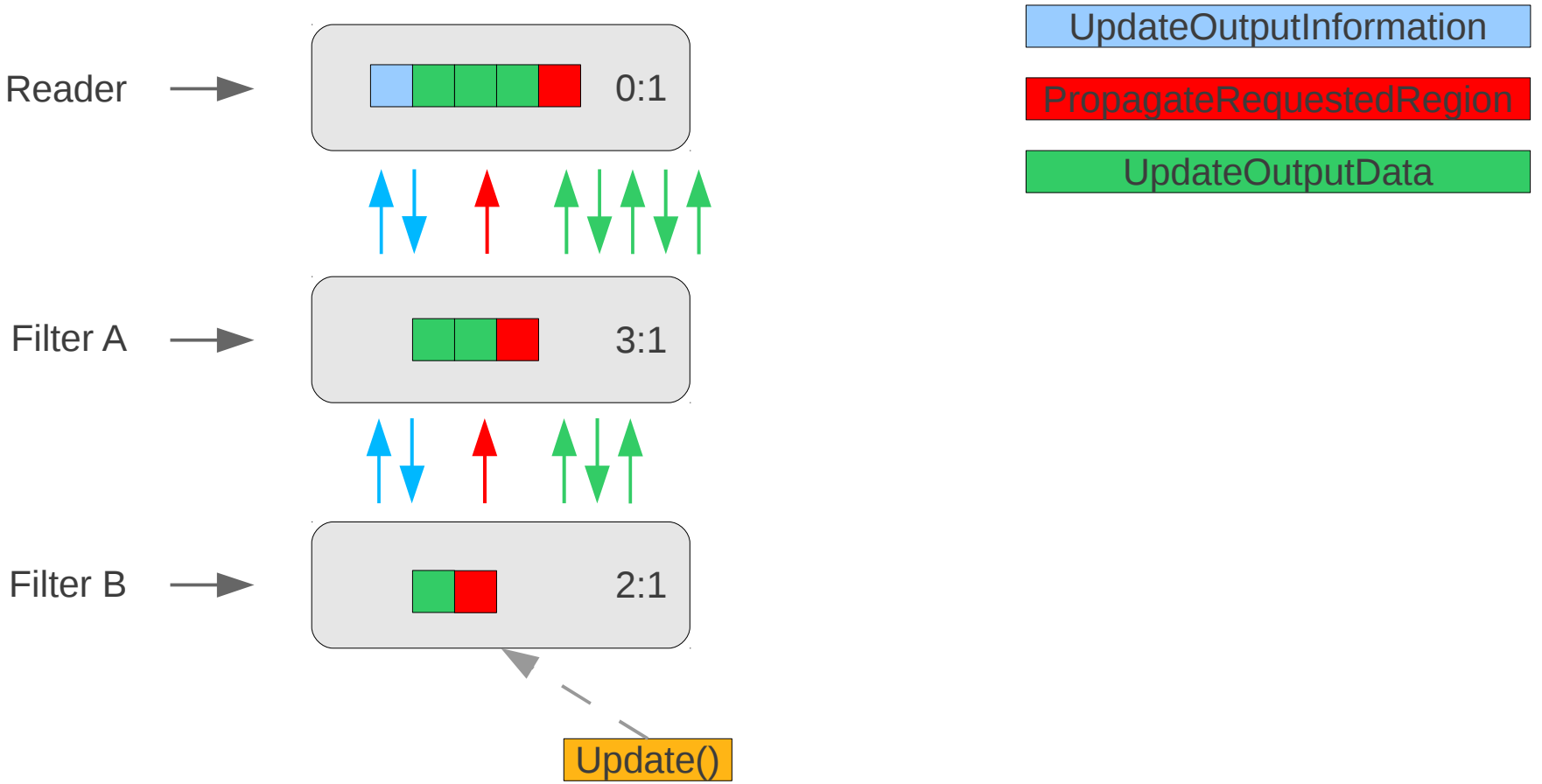

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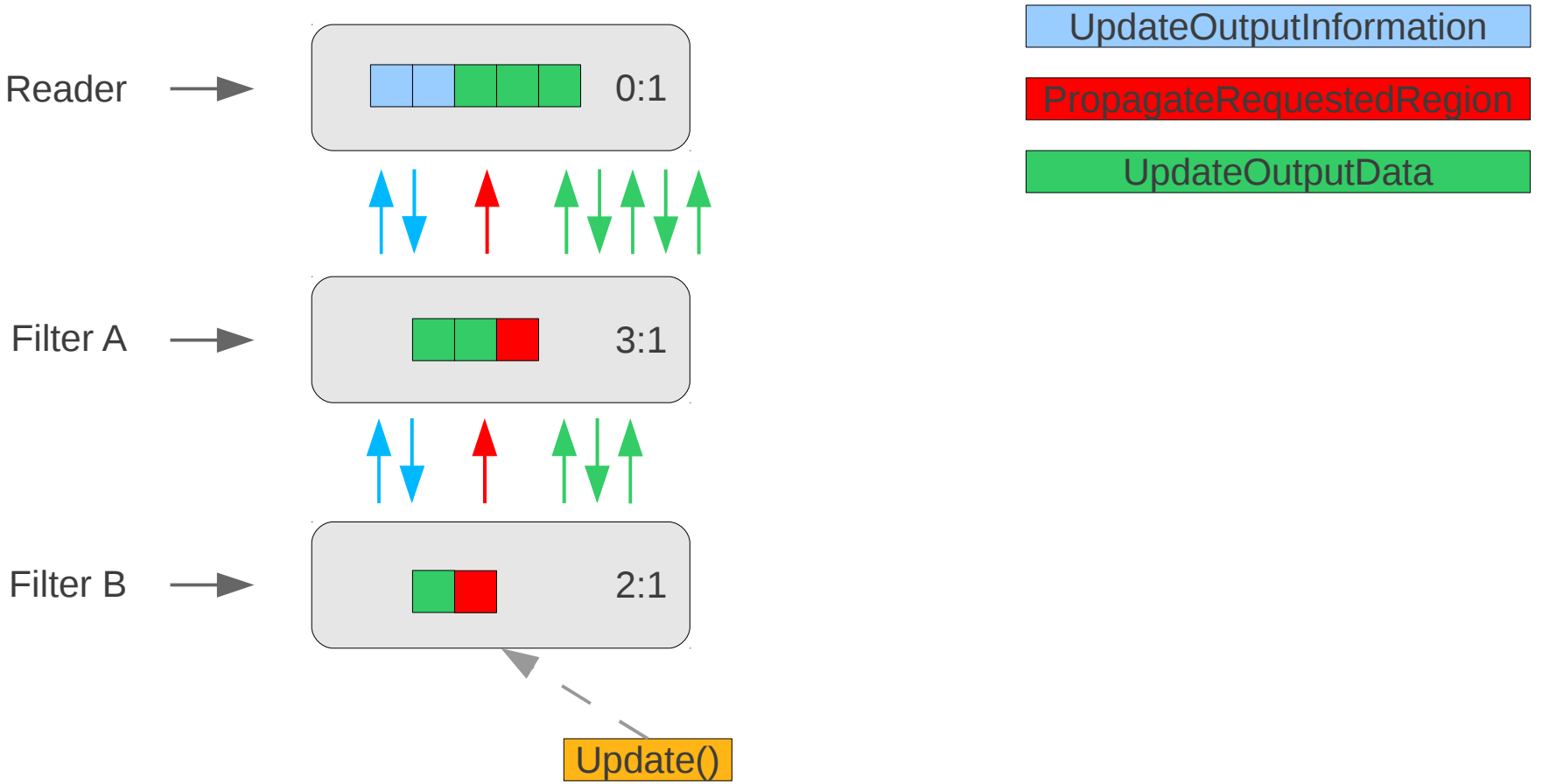

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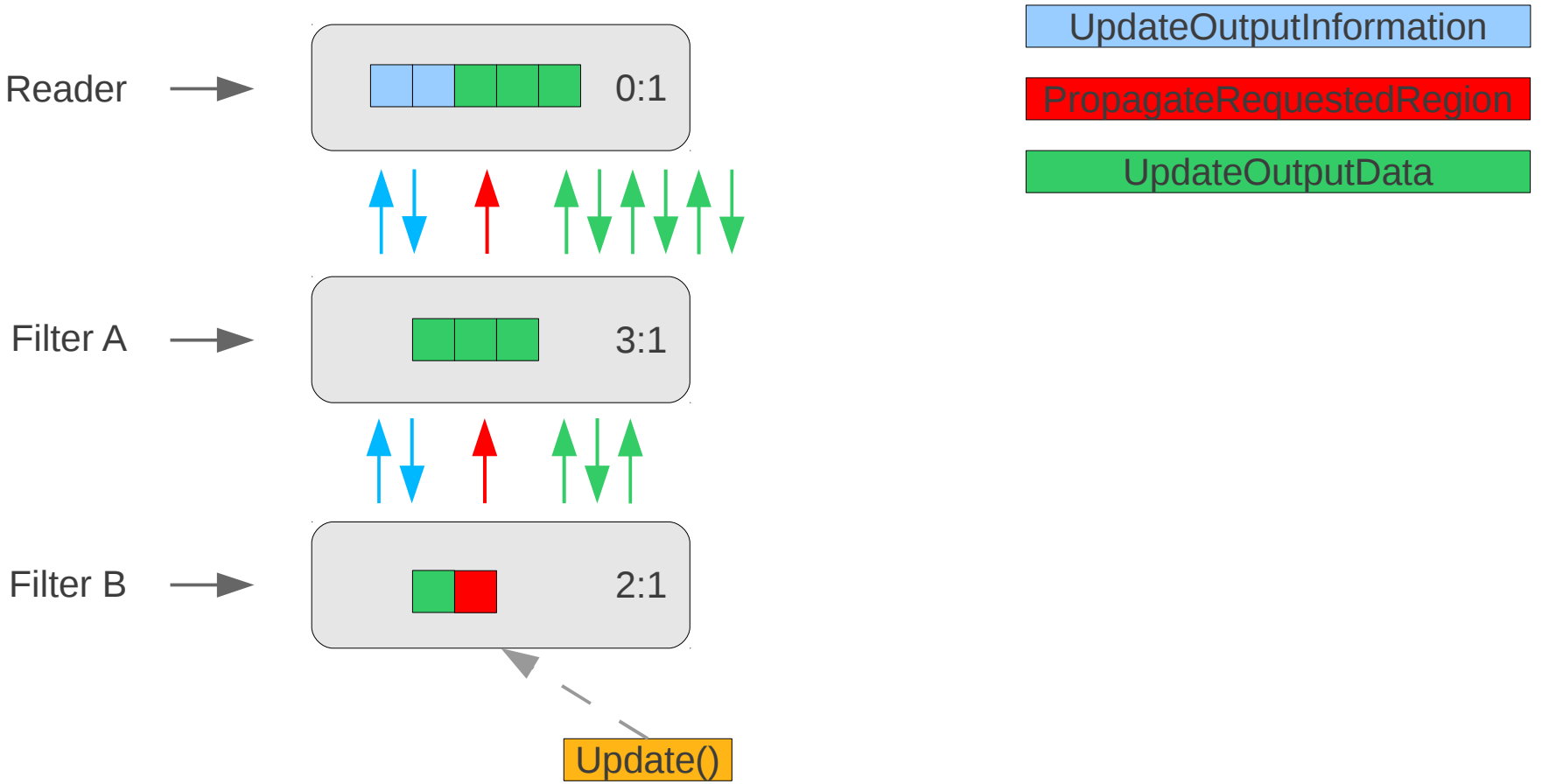

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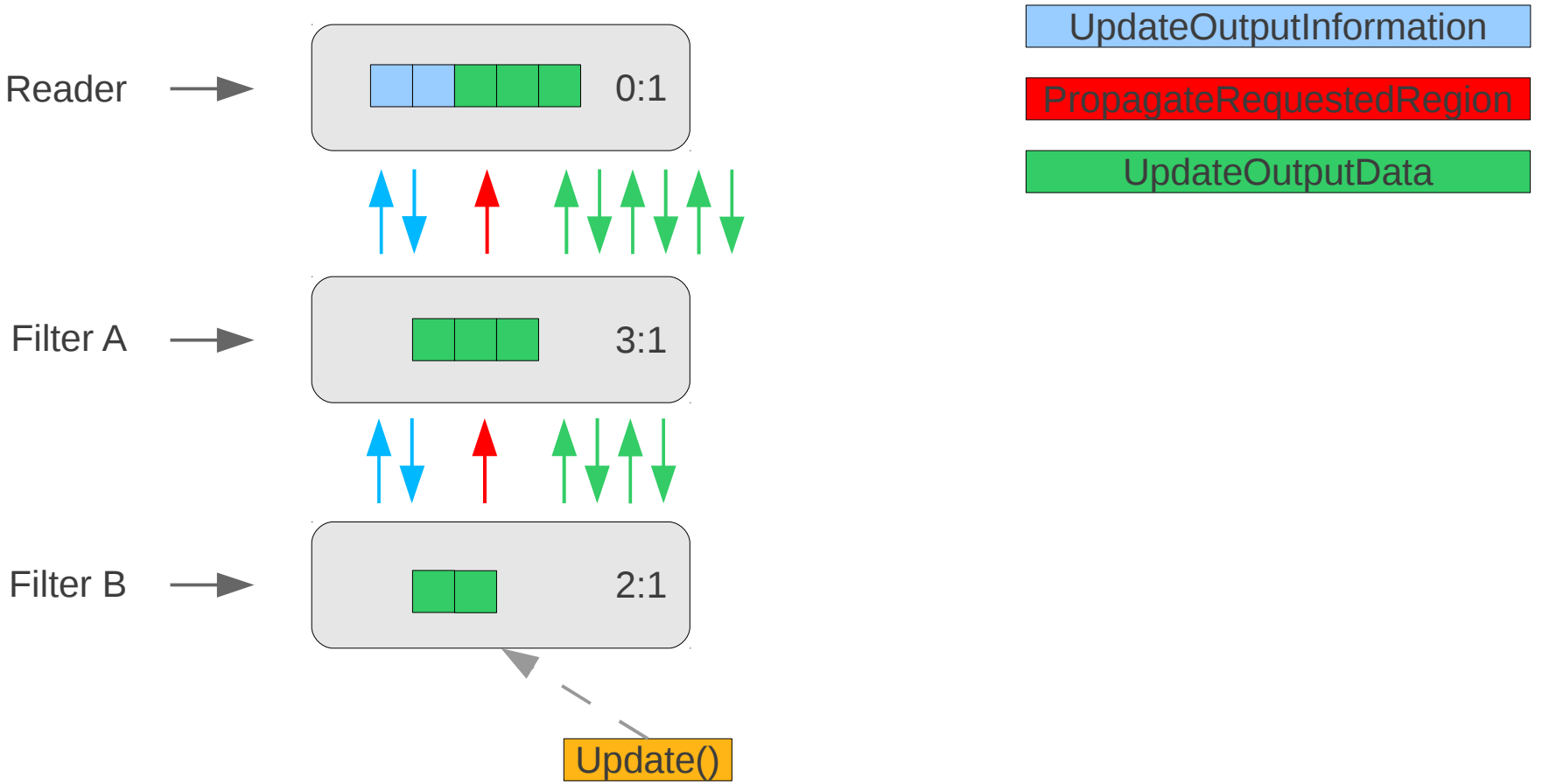


OpenCV / VXL Bridges

Single Image Bridges

- itk::OpenCVImageBridge
  - IplImage ↔ itk::Image
  - cv::Mat ↔ itk::Image

- itk::VXLImageBridge (forthcoming)
  - vil_image ↔ itk::Image
  - vidl_frame ↔ itk::Image

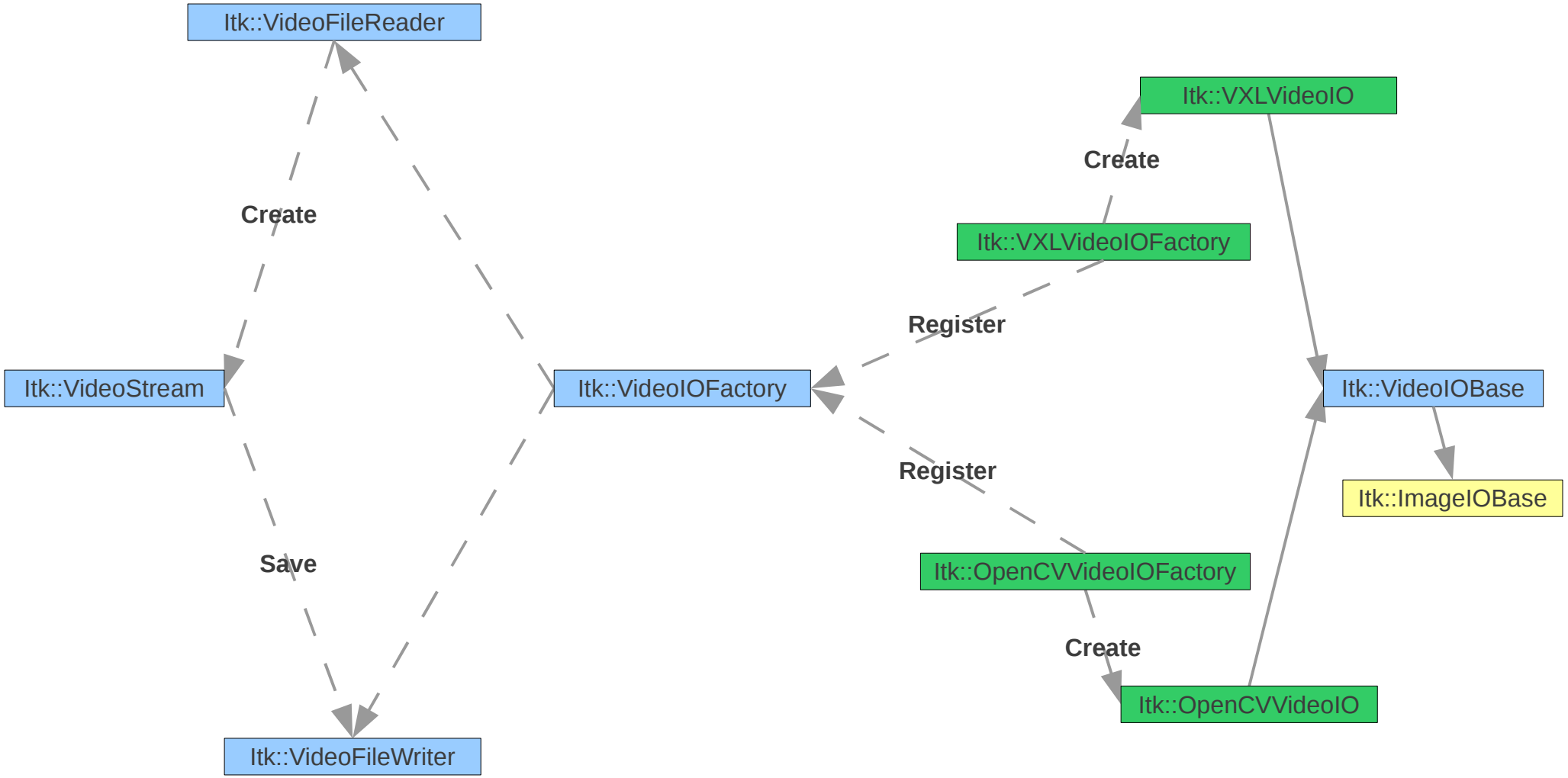
Video Bridges

- itk::OpenCVVideoCapture
  - Subclass of OpenCV's cv::VideoCapture
  - Takes itk::VideoStream as input
  - Triggers pipeline attached to input if necessary

- itk::vidl_itk_istream
  - Subclass of VXL's vidl_istream
  - Takes itk::VideoStream as input
  - Triggers pipeline attached to input if necessary

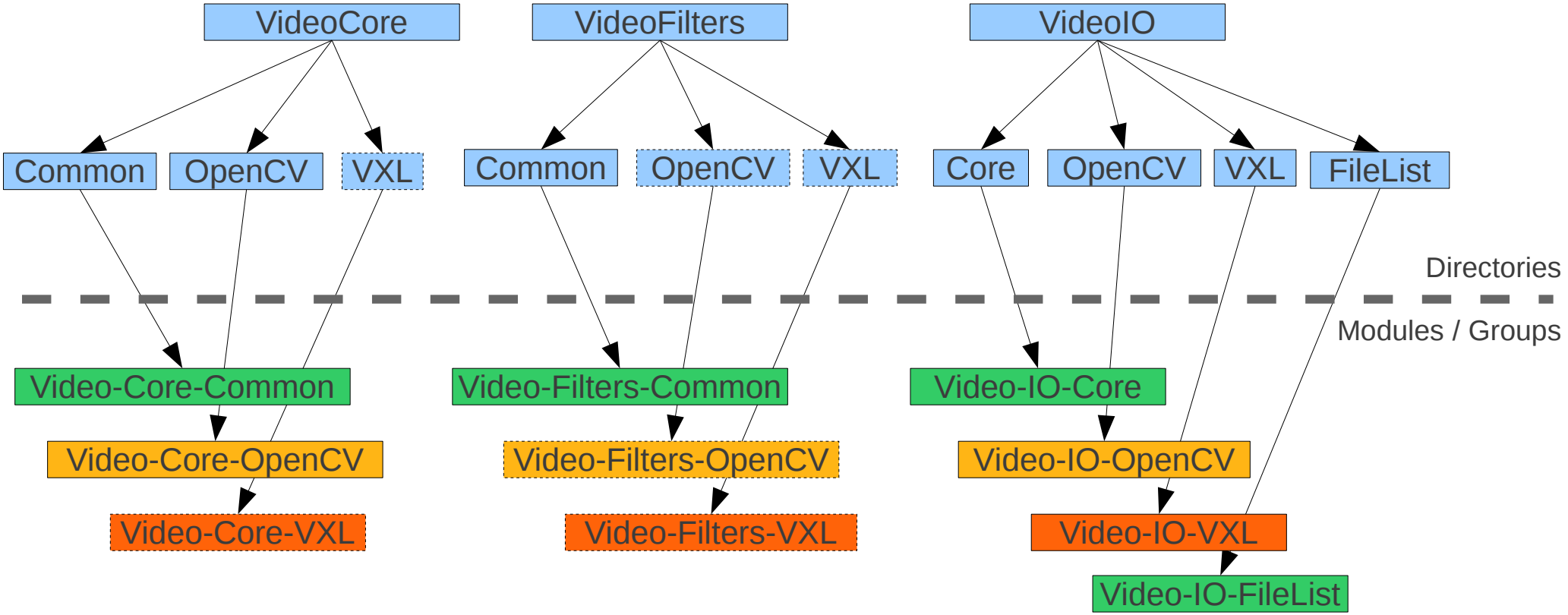
IO Mechanism

IO Mechanism



Module Structure

Module Structure - Current

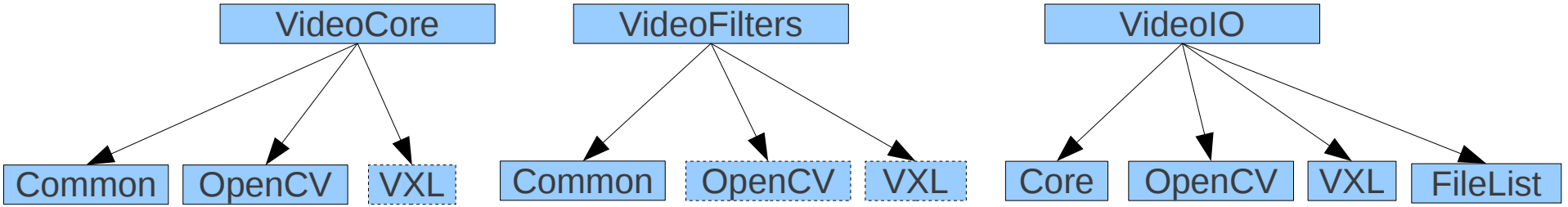


Group_VideoCommon

Group_VideoOpenCV

Group_VideoVXL

Module Structure – Desired (?)



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Directories

Modules / Groups

Video-Core-Common

Video-Core-OpenCV

Video-Core-VXL

Video-Filters-Common

Video-Filters-OpenCV

Video-Filters-VXL

Video-IO-Core

Video-IO-OpenCV

Video-IO-VXL

Video-IO-FileList

Group_VideoCommon

Group_VideoOpenCV

Group_VideoVXL

Issues/ToDo

- RealTimeStamp is not a real time stamp
- I/O readers
  - Image sequence as a video (done via file list)
  - Multi-frame DICOM file as a video
  - Video capture
    - sync with Children's National on video reader and on using framework
  - Direct video I/O (using ffmpeg)
- VideoStream → 3-d volume converter
- Handle infinite duration
- Implement timestamp-based flow (vs frame-based flow)
- Implement video filter base classes for multiple inputs and outputs
  - Synchronization of multiple streams
- Avoid memcpy where possible (when wrapping other libraries)
- Ensure frame size is not an intrinsic problem
  - Working with SD video now, but will need to work with HD video
- Implement filters in new video framework (e.g. using OpenCV)
- Translators for other data structures (e.g. OpenCV sequences, tracks, etc.)

END