Multi-Sensor Data Fusion

Class 4: Sensor Fusion

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Presented by:
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This Week's Agenda

Monday	The Sensor Fusion Problem
Tuesday	Algorithms
Wednesday	Sensor Types
Thursday	Sensor Fusion
Friday	Applications

Course Description

The use of multiple, heterogeneous sensors is often necessary. This is the case in areas such as robot control, autonomous vehicles and military aviation. Different skills are required including electrical engineering, computer science and statistics. These systems can be complex and include many control theory concepts. In this class we will go over the problem, describe the types of algorithms and sensors used and finally will give some examples.

Today's Agenda

- System Framework
- Model Development
- Computational Framework
- Conclusion/Next Class

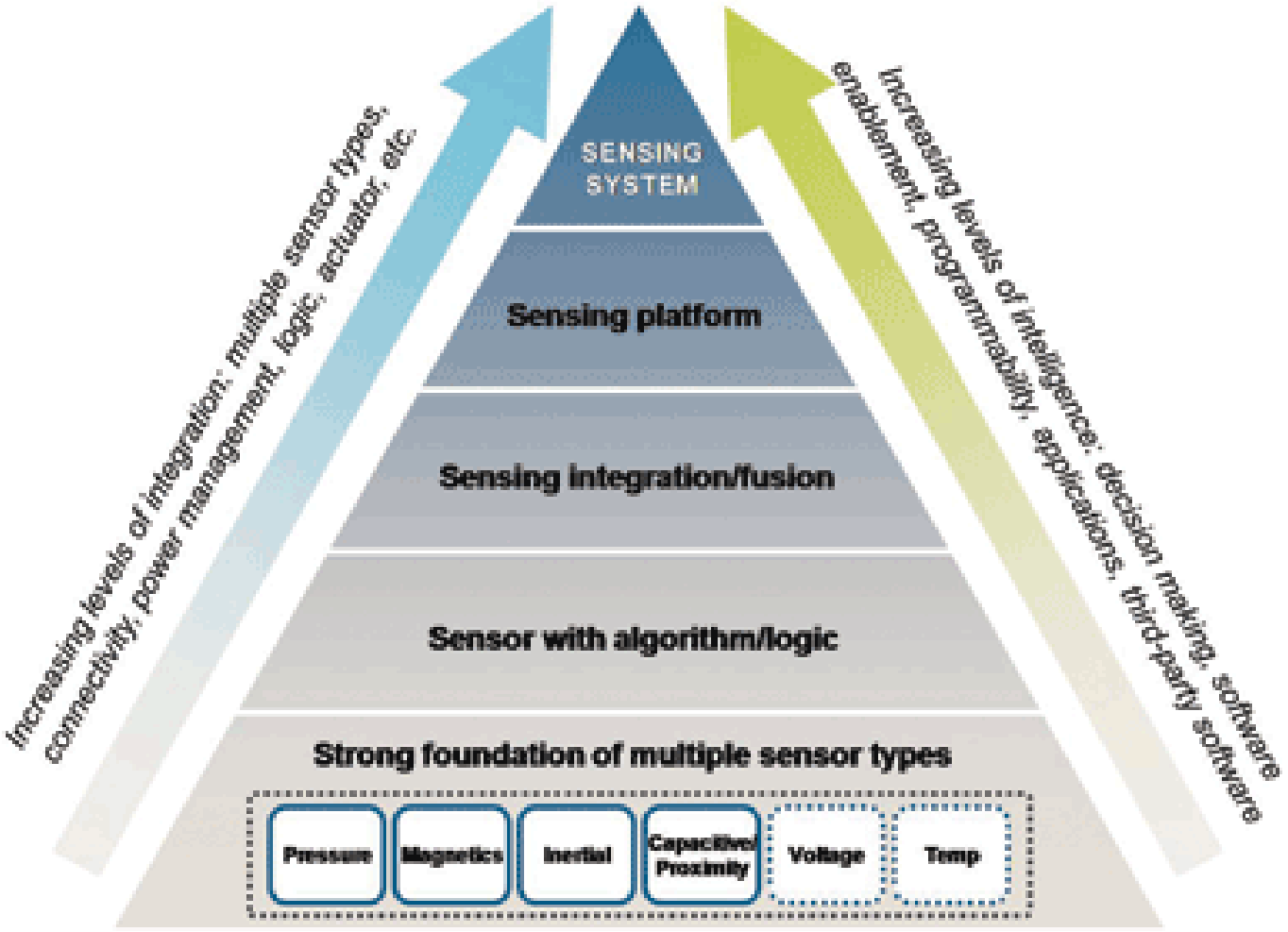
System Framework

- Multi-Sensor Data Fusion (MSDF) systems are typically complex in at least four dimensions
  - Problem definition
  - Algorithms
  - Sensors
  - Computational system
- Effort must be put into problem definition since it drives all the others

System Framework

- In general, there are many considerations and the process will be iterative
- These systems are also typically highly layered, with multiple integration points
- As we have seen, the variety of sensors and other system components can make the process complex
  - A strong systems approach is necessary

System Framework



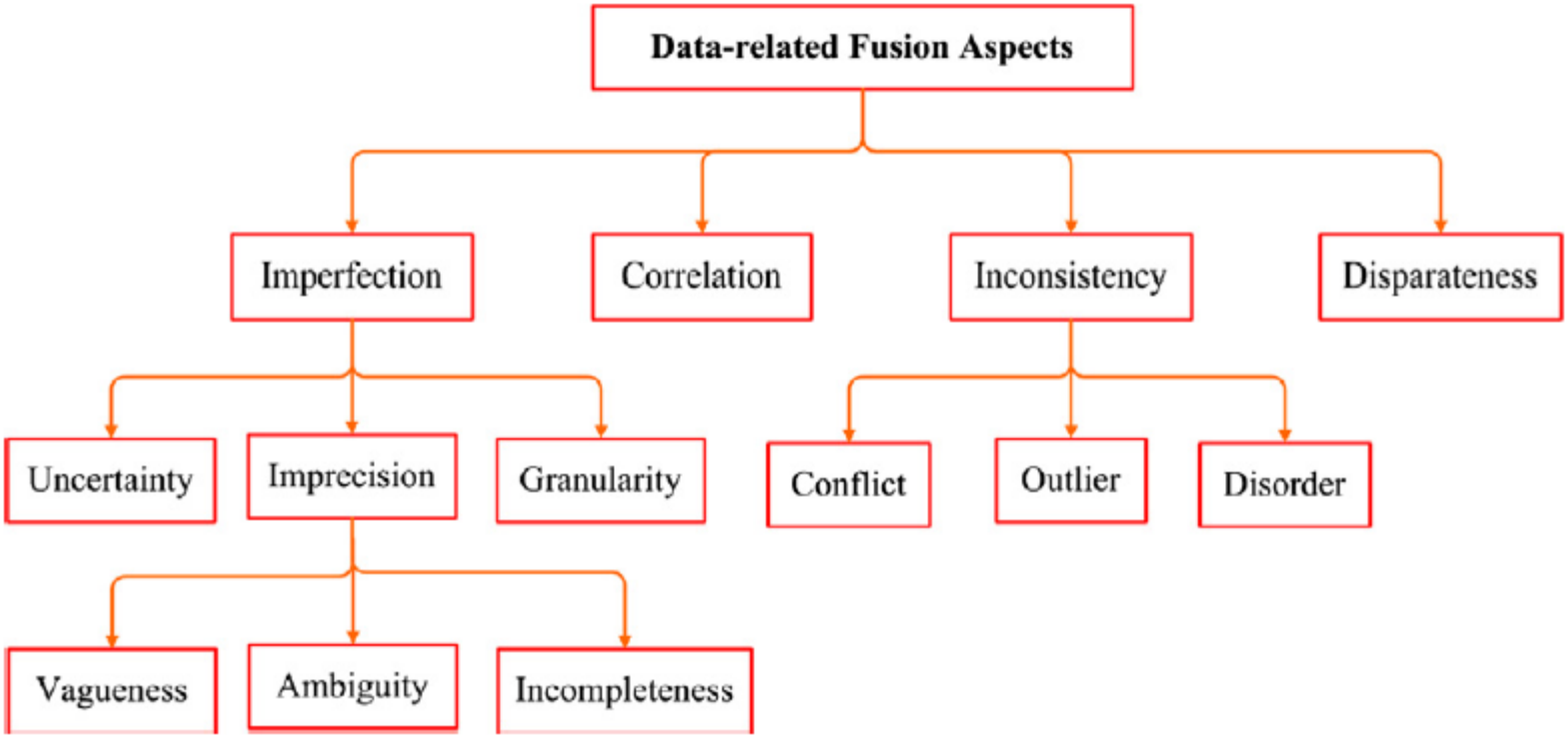
System Framework

- As we can see from the previous slide, there are both physical/implementation issues to consider as well as information theoretic and software issues
- Simulation tools help manage this complexity and the changes that will inevitably need to be made
  - ModelSim (Mentor Graphics)
  - Simulink (MATLAB)

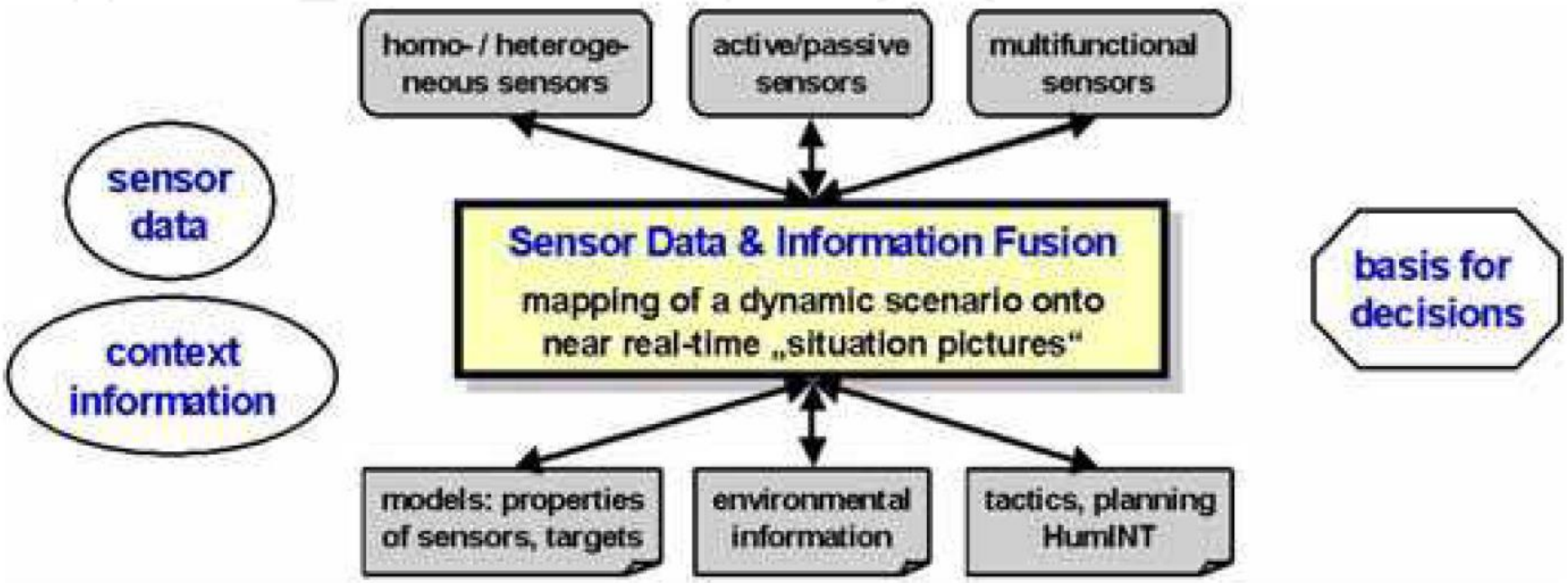
Model Development

- Modelers must consider many dimensions at once
  - The world view
  - Sensors
  - Process (what needs to be accomplished)
  - Device being controlled
- In most cases, perfect knowledge is not obtainable, which means reasoning with uncertainty

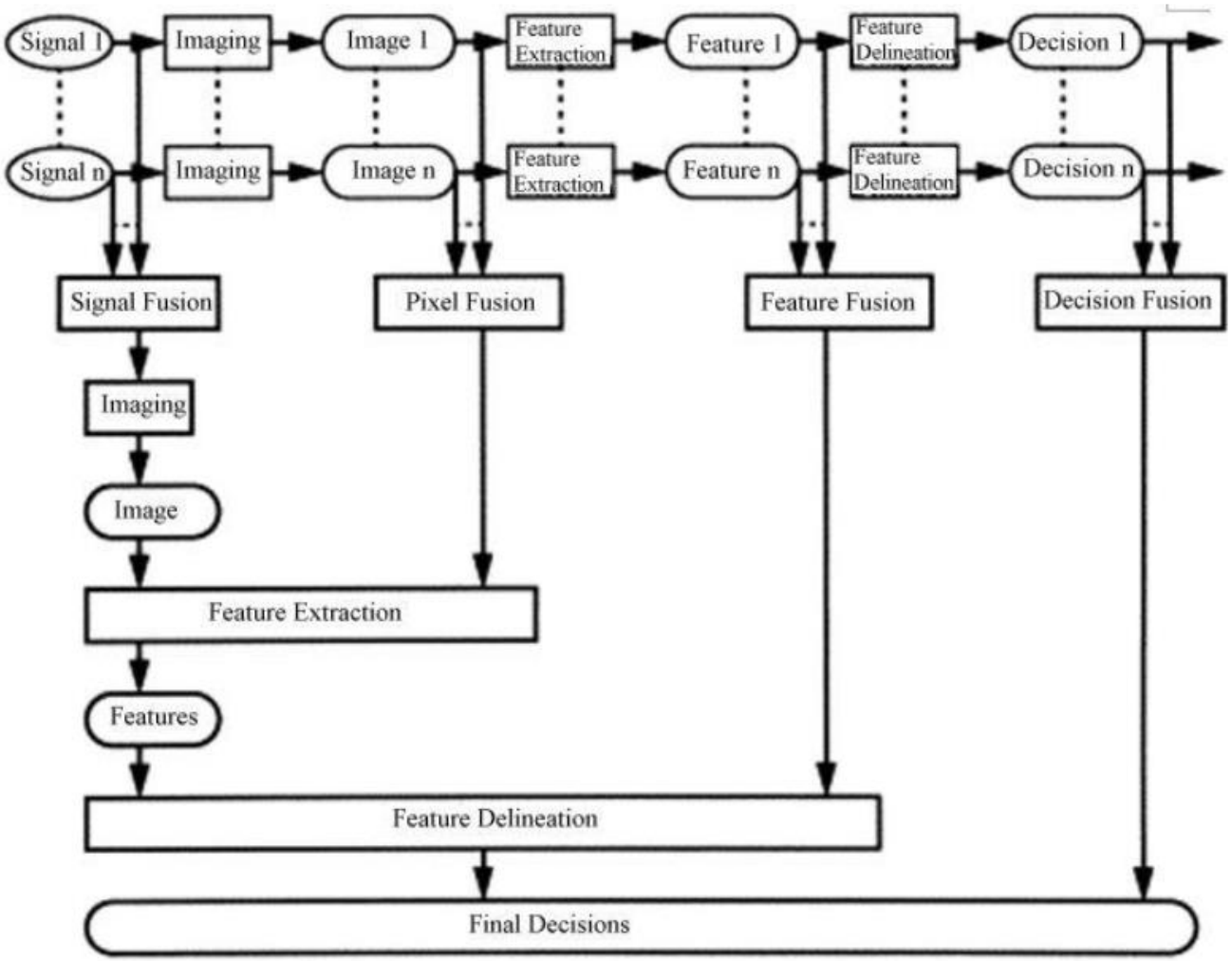
Model Development



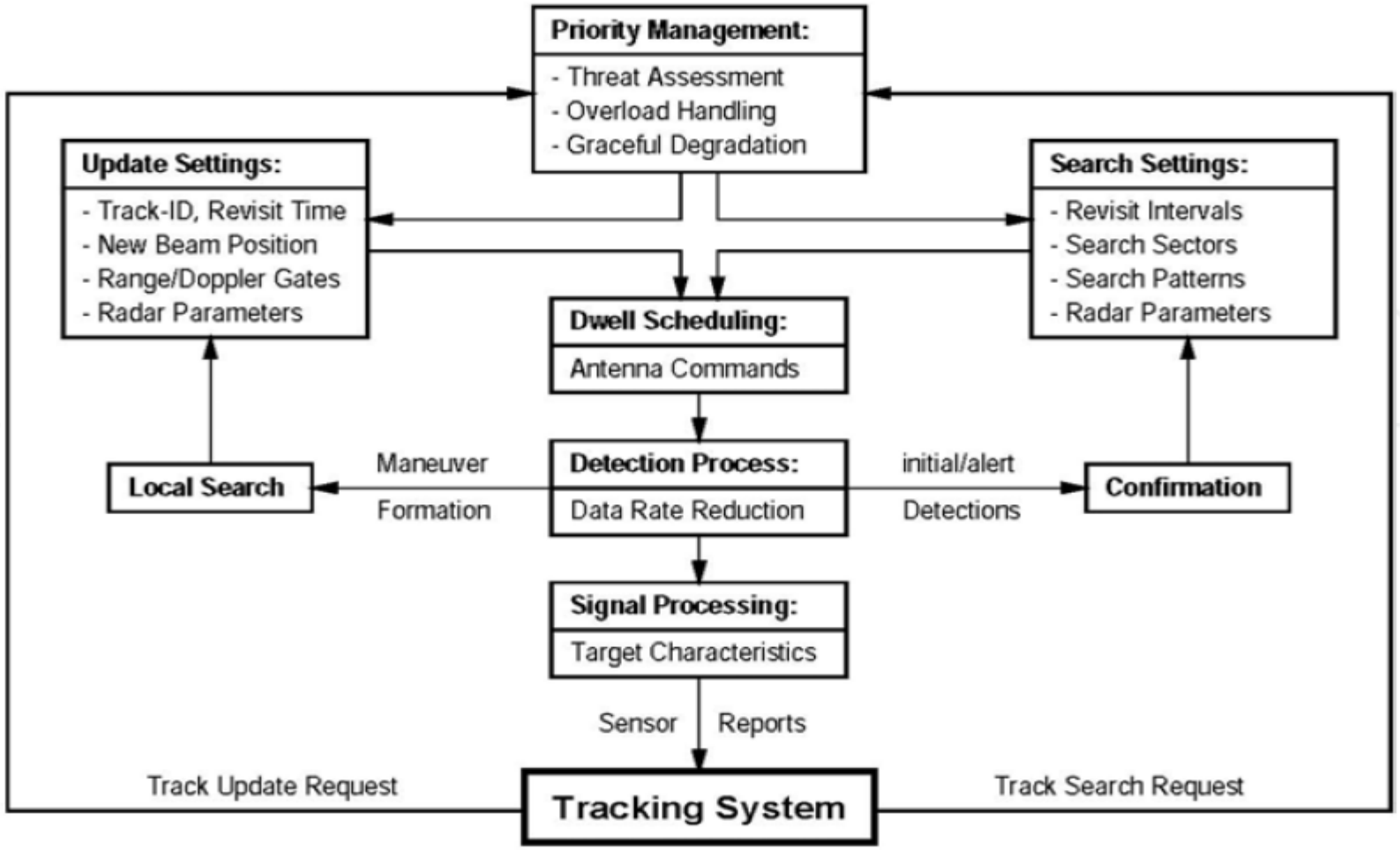
Model Development



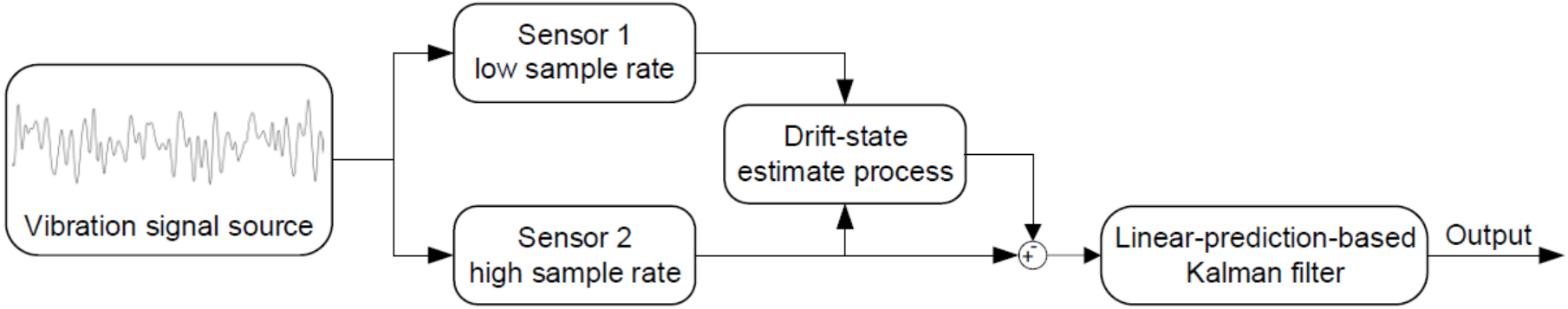
Model Development



Model Development



Model Development



Computational Framework

- There are many choices of architecture and many details to be considered with those choices
  - Centralized
  - Distributed
  - Network
  - System Constraints
    - Size
    - Power
    - Weight

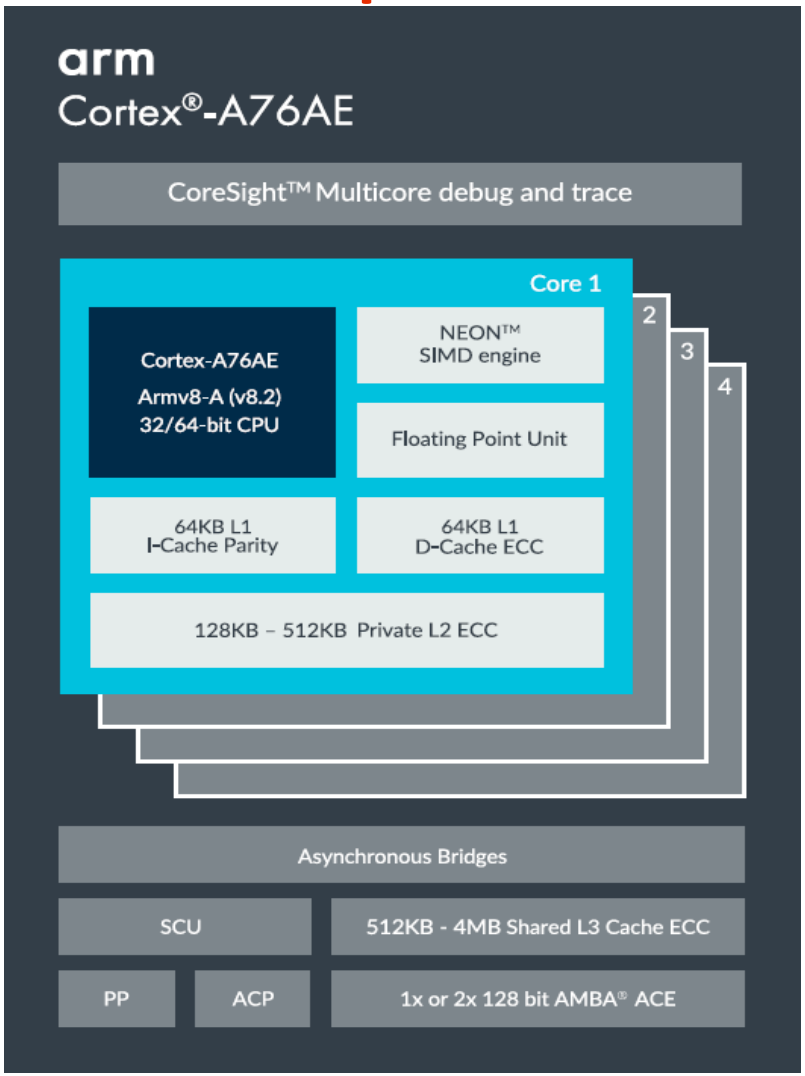
Computational Framework

- Moving sensor processing as close to the sensor as possible will generally simplify development
  - Many modern sensors are programmable and can be designed to give the desired model parameters directly
  - If this is not the case, then processing will have to be done at a centralized processing resource which may cause limitations due to bandwidth constraints

Computational Framework

- Many devices and device types are available. There is no good guidance for one type of architecture
  - ARM processors, such as the CORTEX-A76AE, are specifically targeted at the automotive sector
  - The inclusion of safety features is important in these applications
  - May also need cryptographic capabilities, which will increase processing load

Computational Framework

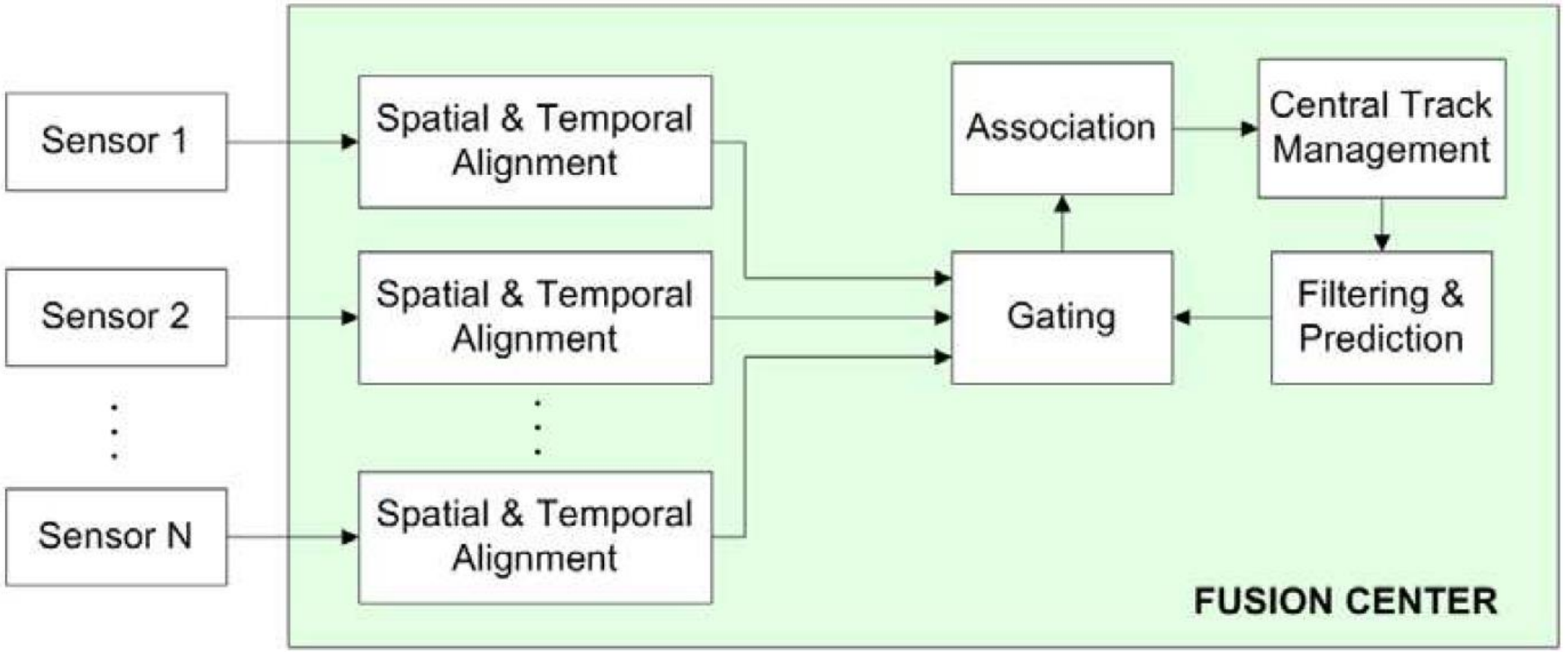


Note:
- Multicore architecture
- Each core has SIMD (image processing) and floating-point capabilities
- Cores can be locked together for fault-tolerant operation

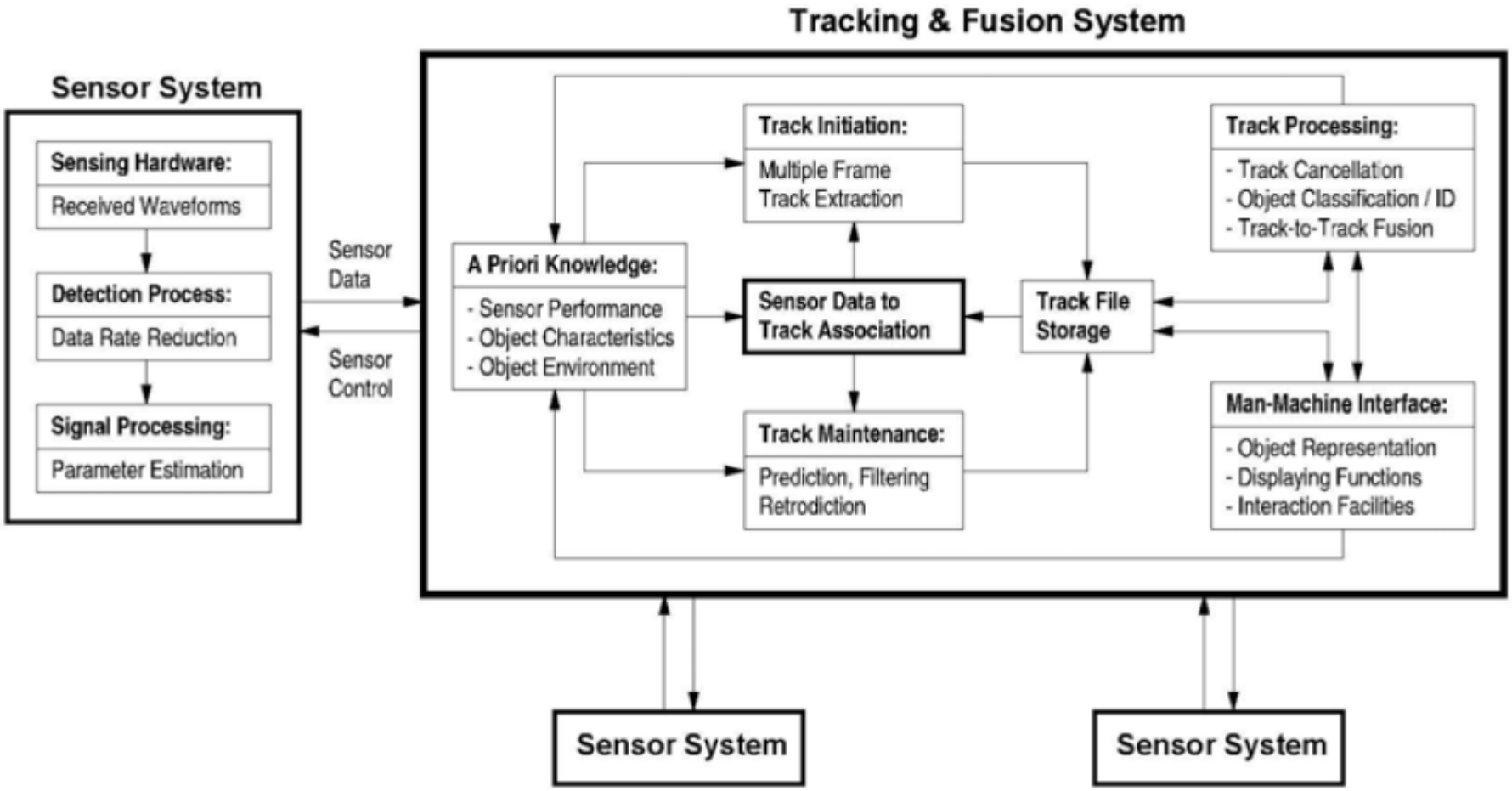
Computational Framework

- Other types of processors have been mentioned
  - GPUs (Graphics Processing Units)
    - High level of parallelism
    - Regular architecture
  - FPGAs (Field Programmable Gate Arrays)
    - Flexible: can be designed to implement the algorithm directly
    - Near ASIC performance
    - Complex to develop

Computational Framework



Computational Framework



Conclusion/Next Class

- Today we looked at the implementations of the MSDF problem
- Consideration was given to the system level, model development and computation
- There are no easy answers
- Tomorrow we will go into some applications, such as self driving vehicles