ASAM OSI Flatbuffers Report

Summary

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Background

- Current OSI: Protobuf for (de)serialization
- Change to Flatbuffers in consideration (idea: faster data access)
- Evaluation by Persival
  - Application Report
  - Performance Report

Application Report

- Flatbuffers: library for (de)serialization
- Access serialized data without parsing / unpacking → fast, small memory footprint
- Data structure definitions:
  - Interface Definition Language (IDL)
  - Automatic conversion of proto-files to IDL
  - Compiler (flatc): C++ headers for usage
  - Message (proto) ←→ Table / Struct (flat)
  - Structs: faster access, no backward compatibility if extended
- Copying SensorView to SensorData currently not possible
- Two ways of using Flatbuffer
  - **Builder API**: standard
  - **Object API:** like Protobuf, slower than builder
- Builder-API
  - Fill data structures inside-out
  - More lines of code than Protobuf
  - No explicit serialize-call (builder.finish)
- Object API
  - More intuitive for Protobuf users, mutable
  - Lower performance, not recommended
- Example conversion on Github
  - OSMPDummySource FMU
    - Creates SensorView
    - Creates + adds N MovingObjects
    - Positions & velocities depend on simulation time
  - OSMPDummySensor FMU
    - Receives SensorView
    - Filters objects (range, FOV)
    - Creates new objects in SensorData

Performance Report

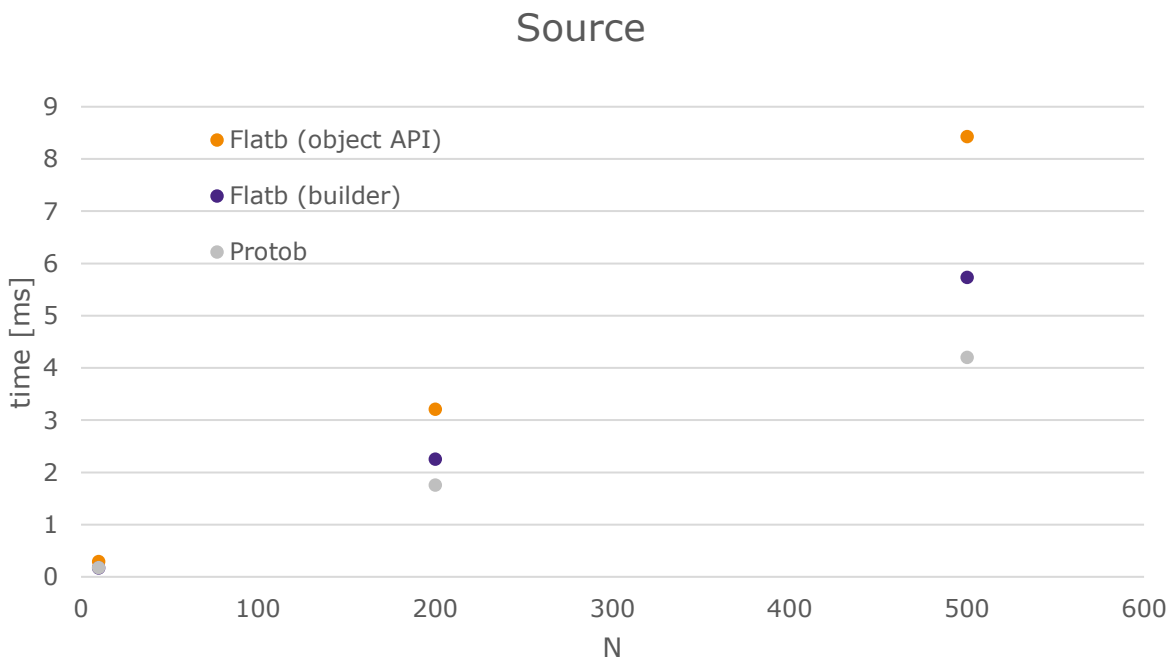
- Compares Protob. and Flatb. versions of FMUs
- Timing measurement in FMU code
  - Source
    - Generation
    - Serialization
  - Sensor
    - Deserialization
    - Calculation
    - Serialization
- Avg. over 100 time steps
  - Ok for Lidar tests
  - Too short for object list tests (high fluct.)
  - 5000 time steps for own object list tests

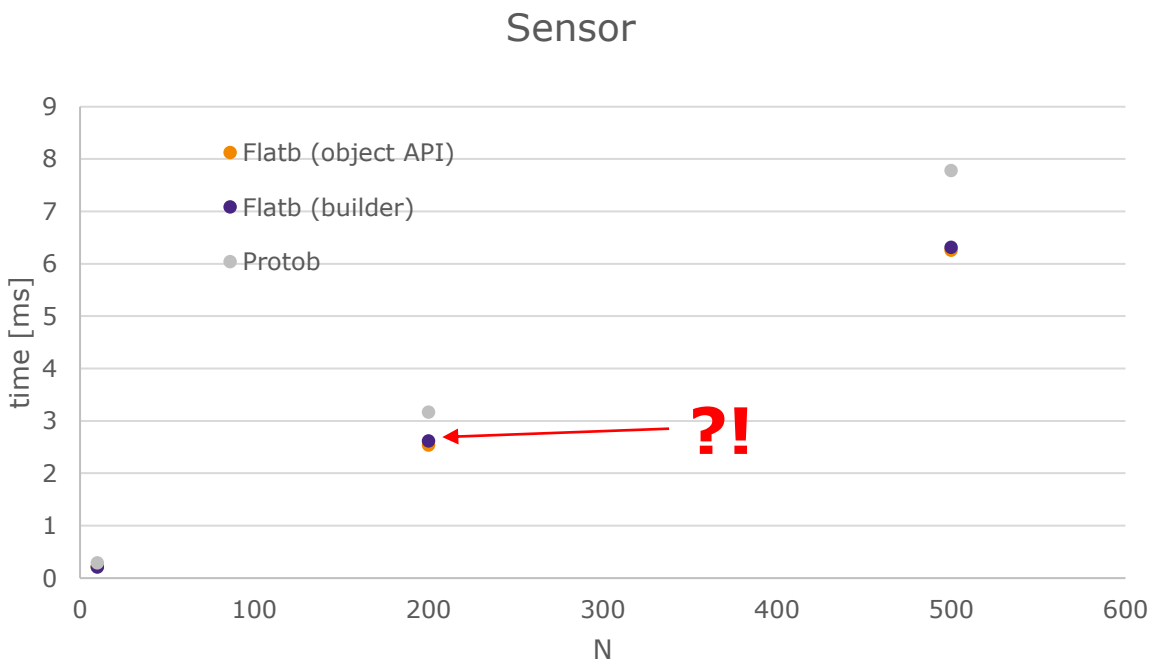
- Test cases
  - Lidar reflections (100k, 400k, 830k)
  - Moving objects (10, 200, 500)
  - Debug vs. Release
  - Builder vs. Object API
  - Tables vs. Structs

Evaluation Subject	Flatbuffers		Protobuf	
	Source in ms	Model in ms	Source in ms	Model in ms
829,440 reflections, 10 objects	43	9	27	66
400,000 reflections, 10 objects	20	4	13	32
100,000 reflections, 10 objects	5	1	3	8
10 objects	0	0	0	0
200 objects	1	1	1	1
500 objects	2	2	2	2
Debug build	352	117	132	258
Flatbuffers Object API	68	9	-	-
Reflections, Vector3D etc. as Structs	28	5	-	-
Trace File Player (700,000 refl.)	1	7	7	49

Performance testing, 1st run – objects

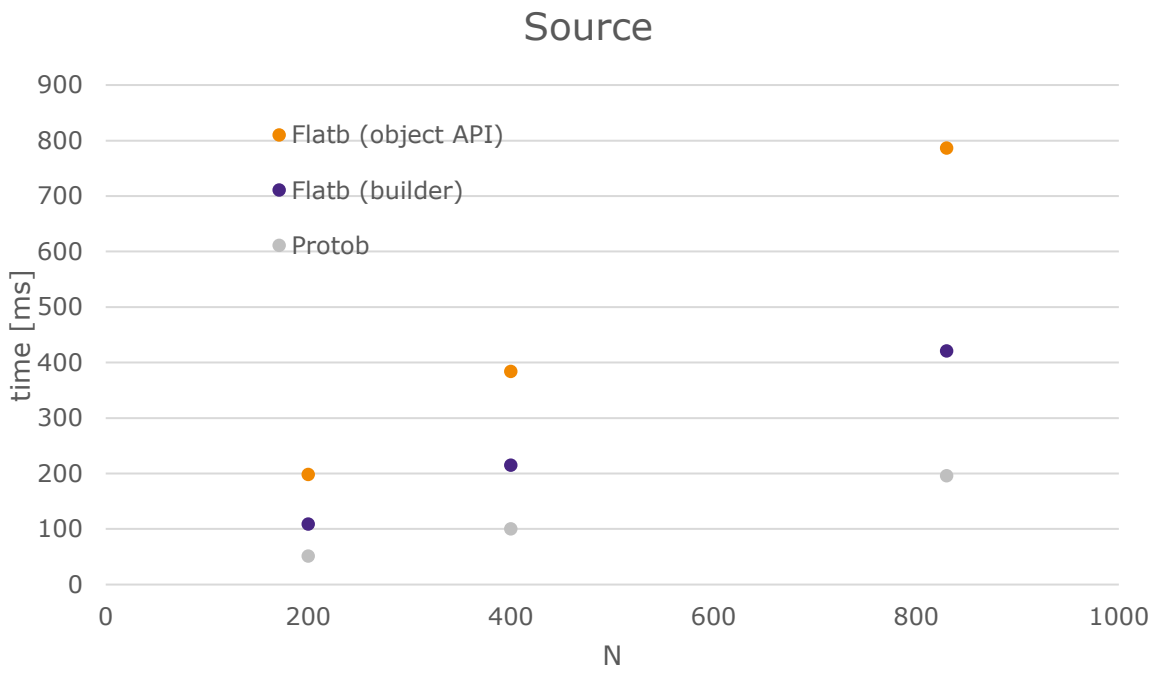
- Based on **original branches created by Persival** (*feature/flatbuffers_examples*, *flatbuffers_object_api*)
- Two issues:
  - Some Lidar data structures always created (in case of no received reflections)
  - Same results for sensor with Builder-API and Object-API
    - Code diff.: DummySensor was not converted to Object API → INVALID comparison
- Modification of DummySensor:
  - Use only Object-API (in corresponding branch)
  - Avoid unnecessary Lidar data structures

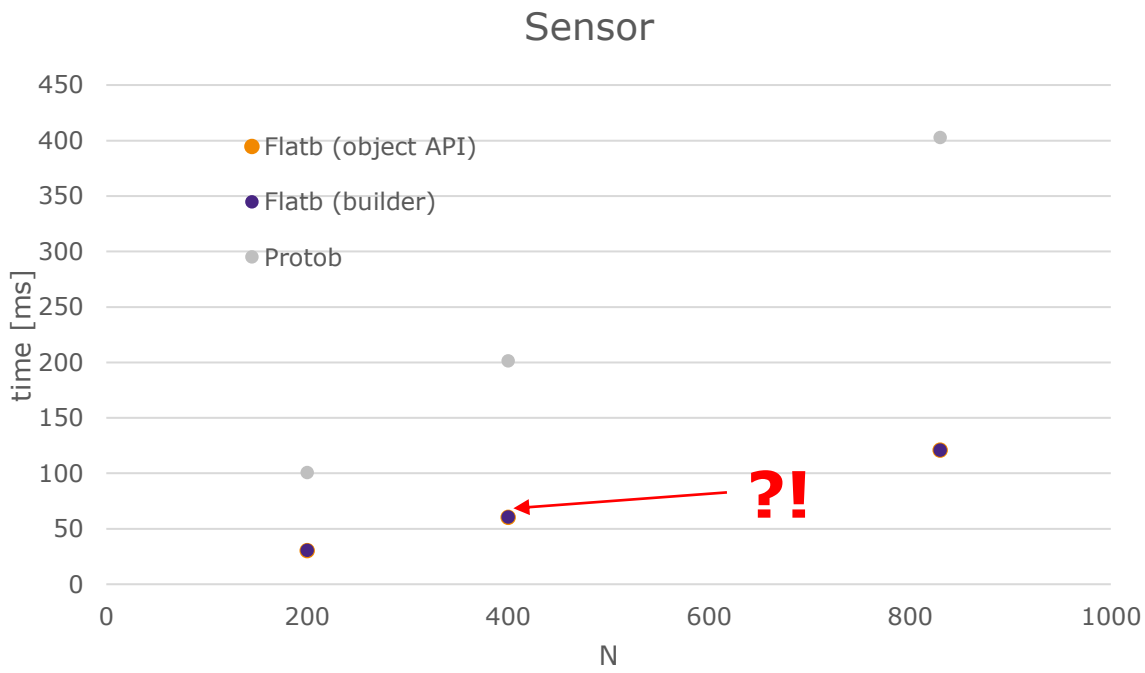




Performance testing, 1st run – Lidar

- Based on original branches created by Persival (*feature/flatbuffers_examples*, *flatbuffers_object_api*)
- Same issues as for object list tests

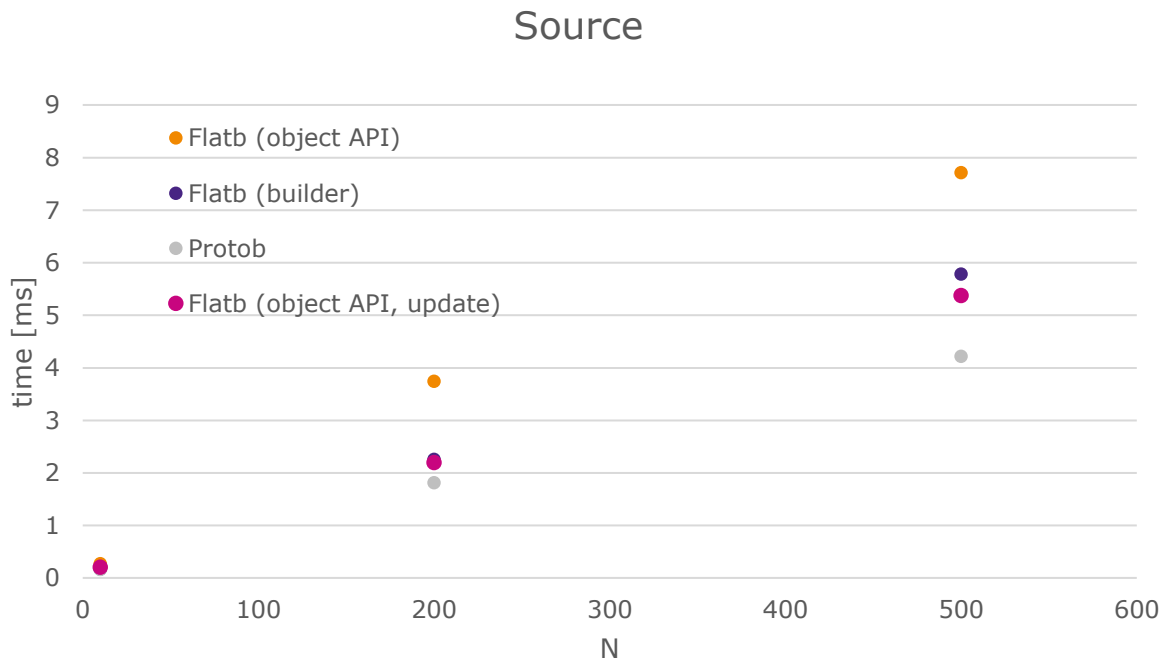


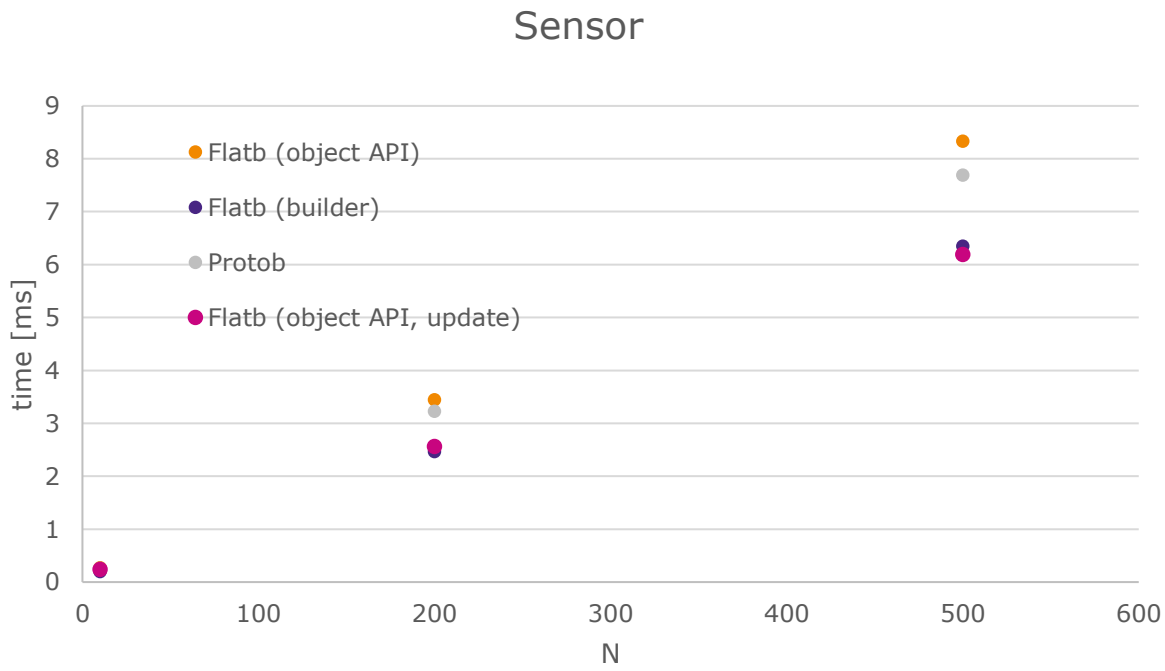


Performance testing, 2nd run – objects

- Based on **modified branches**
- Different results for Builder-API and Object-API (as expected)
- Flatb. with Object API: slowest execution time for source and sensor

Remark:
- Flatb. (Object API) could be used for internal object representation (update objects instead of recreating)
- This was examined after adaption of DummySource and DummySensor (object API, update)





Performance testing, 2nd run – 10 objects

Persival report

DummySource (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	0,000	0,000	
Serialize	0,000	0,000	
Total	**0,000**	**0,000**	**0,000**

DummySensor (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	0,000	0,000	
Calculation	0,000	0,000	
Serialize	0,000	0,000	
Total	**0,000**	**0,000**	**0,000**

Own experiments

DummySource				
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*	*Flatb (object_API, update) [ms]*
Generate	0,119	0,160	0,174	0,095
Serialize	0,040	0,006	0,096	0,110
Total	**0,15863**	**0,16595**	**0,270**	**0,204**

DummySensor				
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*	*Flatb (object_API, update) [ms]*
Deserialize	0,052	0,019	0,020	0,023
Calculation	0,155	0,171	0,183	0,140
Serialize	0,051	0,010	0,069	0,080
Total	**0,2579**	**0,19973**	**0,273**	**0,243**

Performance testing, 2nd run – 200 objects

Persival report

DummySource (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	1,000	1,000	
Serialize	0,000	0,000	
Total	**1,000**	**1,000**	**0,000**

DummySensor (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	0,000	0,000	
Calculation	1,000	1,000	
Serialize	0,000	0,000	
Total	**1,000**	**1,000**	**0,000**

Own experiments

DummySource				
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*	*Flatb (object_API, update) [ms]*
Generate	1,463	2,248	2,559	1,002
Serialize	0,349	0,010	1,185	1,192
Total	**1,81215**	**2,25821**	**3,744**	**2,193**

DummySensor				
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*	*Flatb (object_API, update) [ms]*
Deserialize	0,627	0,016	0,021	0,016
Calculation	2,135	2,437	2,853	1,975
Serialize	0,467	0,011	0,570	0,575
Total	**3,22948**	**2,46407**	**3,444**	**2,565**

Performance testing, 2nd run – 500 objects

Persival report

DummySource (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	2,000	2,000	
Serialize	0,000	0,000	
Total	**2,000**	**2,000**	**0,000**

DummySensor (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	0,000	0,000	
Calculation	2,000	2,000	
Serialize	0,000	0,000	
Total	**2,000**	**2,000**	**0,000**

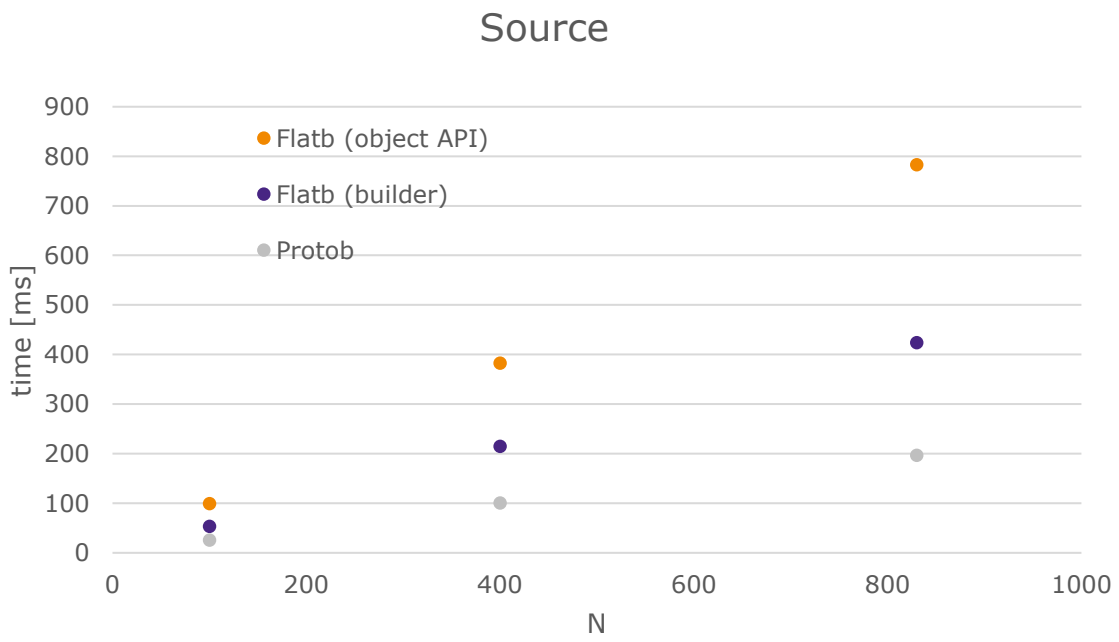
Own experiments

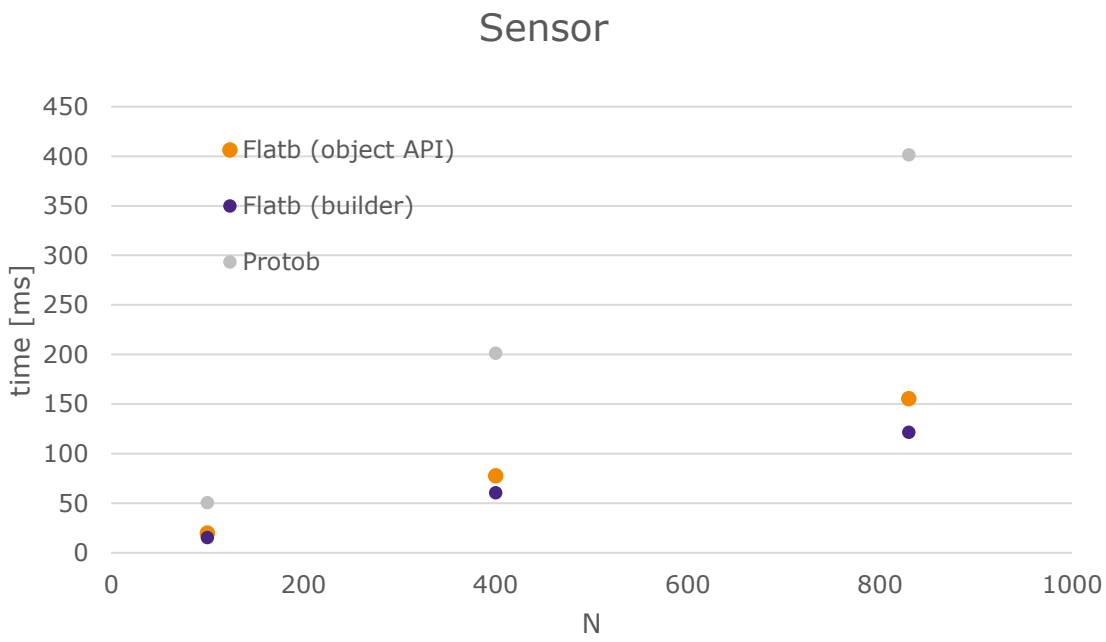
DummySource				
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*	*Flatb (object_API, update) [ms]*
Generate	3,391	5,761	4,828	2,447
Serialize	0,822	0,018	2,881	2,925
Total	**4,21372**	**5,77912**	**7,709**	**5,372**

DummySensor				
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*	*Flatb (object_API, update) [ms]*
Deserialize	1,544	0,016	0,020	0,015
Calculation	5,042	6,319	6,991	4,833
Serialize	1,104	0,015	1,323	1,346
Total	**7,69051**	**6,34965**	**8,334**	**6,194**

Performance testing, 2nd run – Lidar

- Based on **modified branches**
- Different results for Builder-API and Object-API (as expected)
- Different results for source and sensor
  - Source: Flatb. (Object API) slowest
  - Sensor: Protob. slowest, due to Deserialization





Performance testing – 100k lidar reflections

Persival report

DummySource (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	2,000	5,000	
Serialize	1,000	0,000	
Total	**3,000**	**5,000**	**0,000**

DummySensor (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	3,000	0,000	
Calculation	4,000	1,000	
Serialize	1,000	0,000	
Total	**8,000**	**1,000**	**0,000**

Own experiments

DummySource			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	11,886	53,151	39,596
Serialize	13,681	0,645	59,696
Total	**25,56731**	**53,79666**	**99,292**

DummySensor			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	20,940	0,020	0,033
Calculation	16,207	15,467	13,148
Serialize	13,430	0,051	6,756
Total	**50,57641**	**15,538795**	**19,937**

Performance testing – 400k lidar reflections

Persival report

DummySource (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	8,000	18,000	
Serialize	5,000	2,000	
Total	**13,000**	**20,000**	**0,000**

DummySensor (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	12,000	0,000	
Calculation	15,000	4,000	
Serialize	5,000	0,000	
Total	**32,000**	**4,000**	**0,000**

Own experiments

DummySource			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	46,975	212,188	155,393
Serialize	53,596	2,447	227,332
Total	**100,57111**	**214,63503**	**382,725**

DummySensor			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	83,428	0,023	0,078
Calculation	64,589	60,604	51,338
Serialize	53,393	0,022	26,413
Total	**201,4107**	**60,64816**	**77,829**

Performance testing – 830k lidar reflections

Persival report

DummySource (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	17,000	40,000	15,000
Serialize	10,000	3,000	53,000
Total	**27,000**	**43,000**	**68,000**

DummySensor (REPORT)			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	26,000	0,000	0,000
Calculation	30,000	9,000	9,000
Serialize	10,000	0,000	0,000
Total	**66,000**	**9,000**	**0,000**

Own experiments

DummySource			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Generate	90,368	418,972	311,465
Serialize	106,505	4,784	471,674
Total	**196,87273**	**423,75561**	**783,139**

DummySensor			
	Protob [ms]	*Flatb (builder) [ms]*	*Flatb (object_API) [ms]*
Deserialize	166,630	0,023	0,103
Calculation	128,216	121,248	102,556
Serialize	106,638	0,416	52,934
Total	**401,48363**	**121,6873**	**155,593**