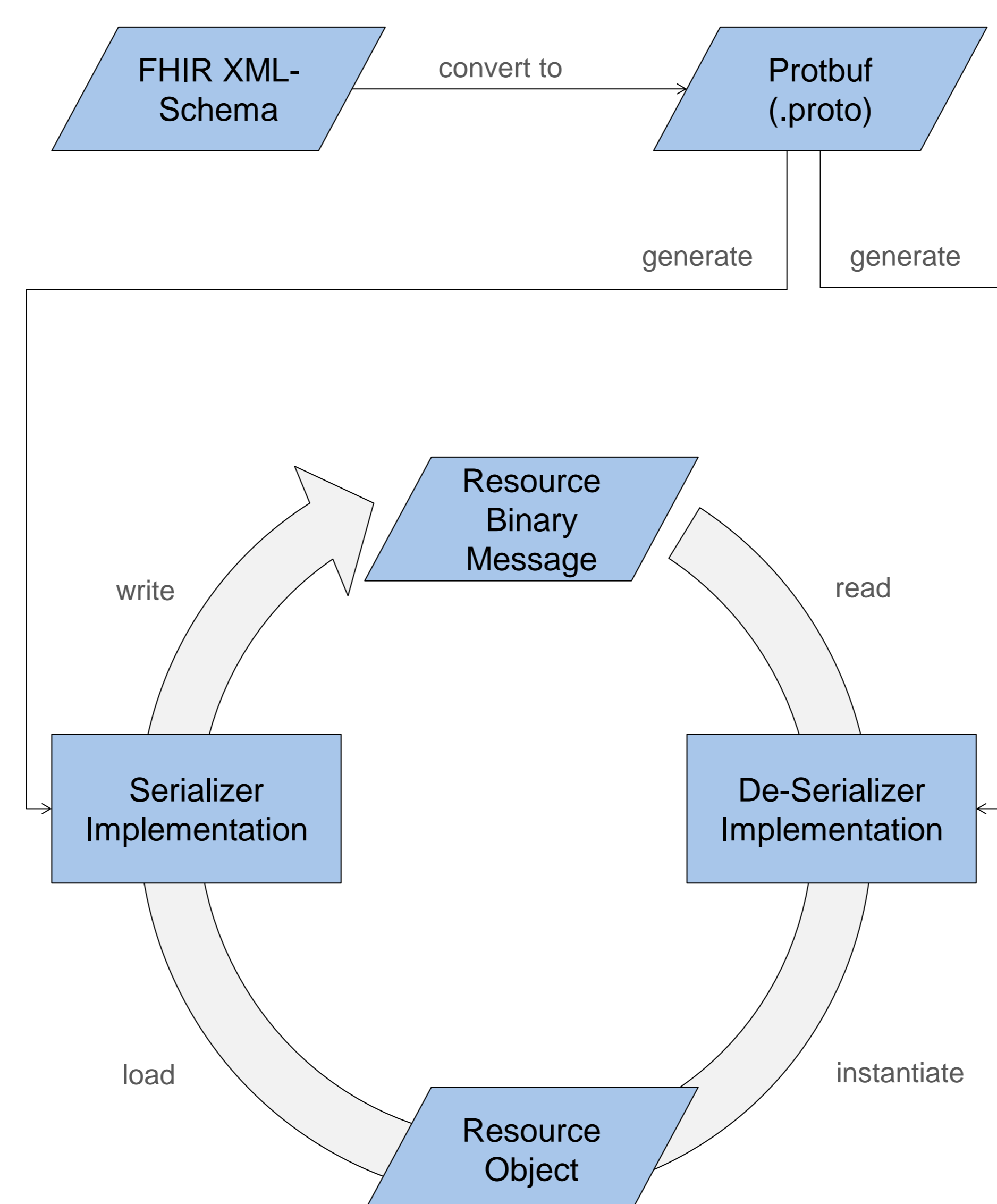


## Introduction

- The Health Level Seven (HL7)-Protocol provides the **most relevant standard** for data transfer and communication within Hospital Information Systems (HIS) [1].
- The upcoming **HL7 Fast Healthcare Interoperability Resources (FHIR)** utilizes, among others, XML and Representational State Transfer (REST) [2].
- FHIR resources have to be **serialized, transmitted and deserialized** during each data exchange.
- With vast amounts of medical (especially mobile) devices waiting to be integrated in hospital information systems in the future, this faces challenges concerning computational **performance and bandwidth** load.
- Objective:** Exploration of an alternative binary serialization approach using **Google Protocol Buffers (Protobuf)** to decrease (de-)serialization computation time while also decreasing needed bandwidth.

## Materials and Methods

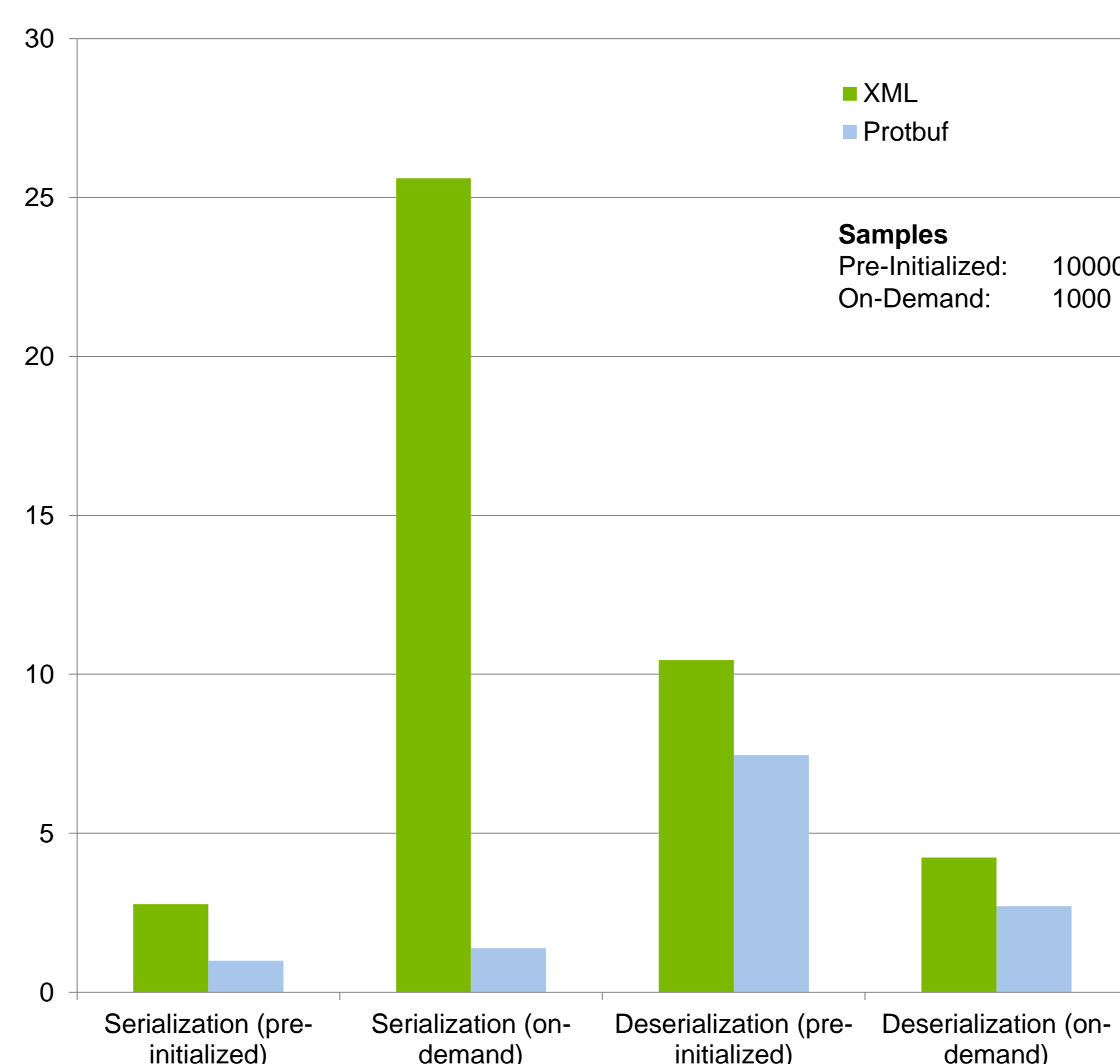
- Protobuf:** Binary format to (de-)serialize objects using three steps; a) Protobuf definition file describing the structure (.proto), b) automated translation of the .proto file into a computer language (e.g. Java) and c) inclusion of generated source in project.
- FHIR:** Set of XML<sup>1)</sup> schema files describing one resource (e.g. patient) in a clinical context. Resources are posted to specific REST endpoints, executing one operation (e.g. admission).
- Transformation:** The public available FHIR-XML schema are converted into .proto definitions, while conserving type safety and cardinalities.
- Evaluation:** A patient's XML schema is transformed into a .proto definition. Sample data containing 29 attributes are repeatedly (de-)serialized on a 800 Mhz system; computation time and transferred data size is measured.



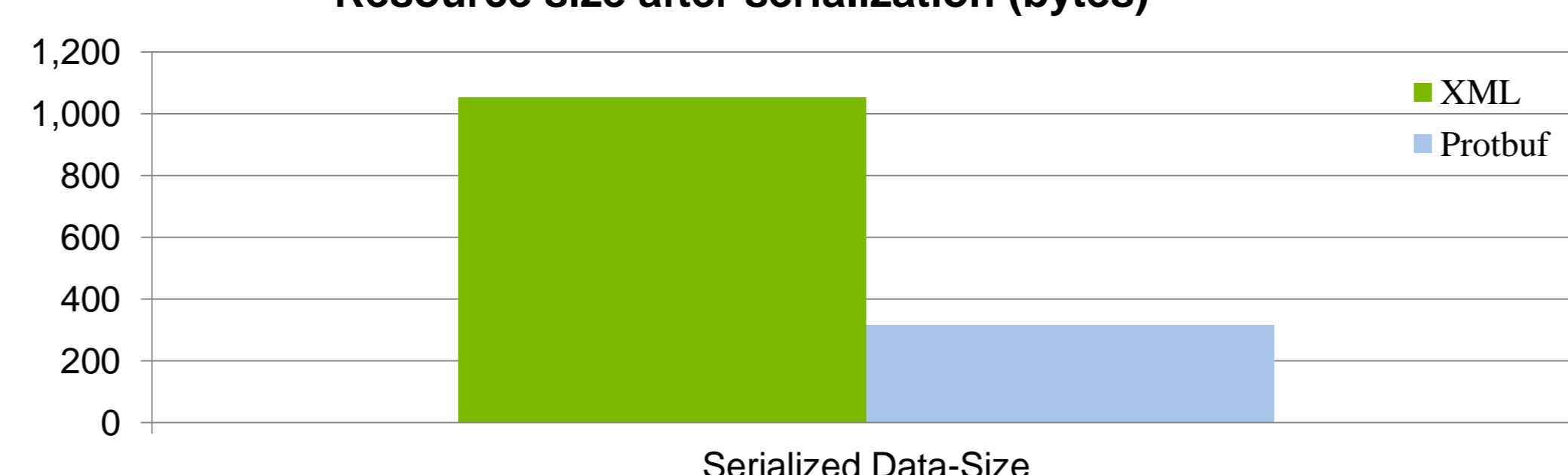
## Results

- Results for 10,000 samples** with pre-initialized (de-)serializers
- Decreased time needed for serialization:** 2,764 ms for XML vs. 984 ms for Protobuf (**35%** of time compared to XML).
- Decreased time needed for deserialization:** 446 ms for XML vs. 7,461 ms for Protobuf (**71%** of time compared to XML).
- Decreased size** of one serialized resource: 1,052 bytes for XML vs. 315 bytes for Protobuf (**30%** of size compared to XML).
- If the (de-)serializer is created on-demand, using 1,000 samples, to decrease the overall memory usage, the Protobuf performance will be even better compared to XML, as the Protobuf (de-)serializer is instantiated much faster.

Computation time for (de)serialization (seconds)



Resource size after serialization (bytes)



## Discussion

- Improved** performance of communication in terms of computation time and bandwidth.
- Transformation of FHIR-XML schema to Protobuf definition could also be done automatically. Currently, the applied approach results in too many intermediate types (decreasing performance) [3].
- Protobuf is available for many languages, so highly portable.
- By replacing HTTP with Protobuf envelope performance will increased even more (but at the price of giving up REST-conformity).
- Main drawback:** Communication not human readable anymore

[1] Benson T. HL7 Version 2. In: Benson T. Principles of Health Interoperability HL7 and SNOMED. Health Information Technology. Springer London; 2012: 101-119.  
 [2] Bender D, Sartipi K. HL7 FHIR: An Agile and RESTful approach to healthcare information exchange. In: Computer-Based Medical Systems (CBMS), 2013 IEEE 26th International Symposium on; 2013. p. 326–331  
 [3] <https://github.com/MarkusHarmsen/xsd2thriftd>

1) Also available as JSON descriptions.

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