IEEE P1752: Standard for Mobile Health Data

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IEEE EMBS Standards Working Groups Collaboration and Best Practices Subcommittee

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Mobile Health / Wearable Data

- Personal health- and behavior-related data collected from sensors and mobile applications could
  - help people and their healthcare providers understand people' health and health states
  - inform people and healthcare providers on health care actions
  - help drive people's changes in health behavior
- Data used by and for health interventions delivered using mobile technologies
  - behavior change (e.g., increasing physical activity, medication adherence,)
  - clinical treatment (e.g., virtual consultation, cognitive behavioral therapy)
- Digital Biomarkers

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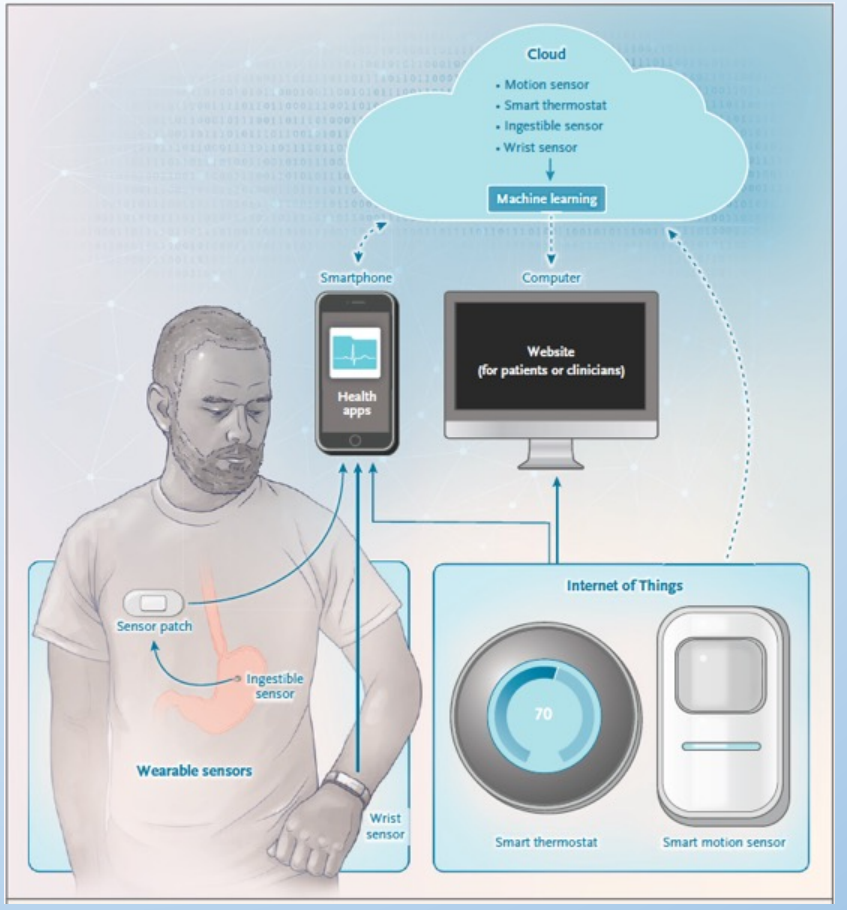
Digital Biomarkers

Digital biomarkers are physiological and behavioral measures collected by means of digital devices such as portables, wearables, implantables or digestibles that characterize, influence or predict health-related outcomes

- e.g., total sleep time, heart rate variability



Sim I. Mobile Devices and Health. N Engl J Med 2019;381:956-68.

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Digital Biomarkers: Assumptions

- Many new digital biomarkers will be defined
- From new sensors and new person-reported outcomes (PROs)
- Continually changing hardware and software
- Increasingly digital biomarkers will combine output from multiple sensors/sources
- Data will flow far and wide to multiple actors for multiple purposes
- **Standards are needed for interoperability**

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Challenges

- Large amounts of data from sensors and apps
- Challenges to align, harmonize, combine data from different sources
- Integration into frontline workflow (EHR-based)
- Standardization helps
  - Syntax
  - Semantics
  - Relevant context
- Privacy, security, ethical concerns

Structural and Semantic Interoperability

Data standards to ensure that meaning is maintained across devices

- Structural interoperability defines the format and syntax of the data exchange
- Semantic interoperability implies a mutual understanding of the meaning of data and metadata

Standardizing mHealth data and metadata

Makes data exchange and reuse **predictable** and **consistent**

Makes data aggregation across multiple sources easier and more accurate

Facilitates development and validation of digital biomarkers

Reduces costs of using mHealth data for care and research

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Open mHealth

- Open mHealth founded in 2011
  https://www.openmhealth.org/
- Broader work on standards funded by an NIH R24 grant (2018-2021)
- Focus on *standardizing data & metadata representation* (schemas) and providing *tools* to use standardized data

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Example Blood Glucose Instance (I)

```
{
    "blood_glucose": {
        "value": 128
    }
}
```

fasting blood glucose

```
{
    "blood_glucose": {
        "unit": "mg/dL"
        "value": 128
    },
    "effective_time_frame": {
        "date_time": "2015-02-05T07:25:00-08:00"
    },
    "temporal_relationship_to_meal": "fasting"
}
```

required

required

optional, but recommended

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Example Blood Glucose Instance (II)

average fasting blood glucose over a 3-month period

```
{
    "blood_glucose": {
        "unit": "mg/dL",
        "value": 128
    },
    "effective_time_frame": {
        "time_interval": {
            "start_date_time": "2021-01-05T07:25:00-08:00",
            "end_date_time": "2021-03-05T07:25:00-08:00"
        }
    },
    "temporal_relationship_to_meal": "fasting",
    "temporal_relationship_to_sleep": "on waking",
    "descriptive_statistic": "average"
}
```

required

required

optional

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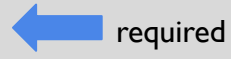
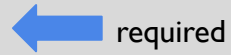
Example Blood Pressure Instance

```
{
    "HP": 124,
    "LP": 82,
    "BPUnit": 0,
    [...]
}
```

```
{
    "systolic": 125,
    "diastolic": 85,
    "bloodPressureUnits": "mmHg",
    [...]
}
```

```
{
    "systolic_blood_pressure": {
        "value": 140,
        "unit": "mmHg"
    },
    "diastolic_blood_pressure": {
        "value": 60,
        "unit": "mmHg"
    },
    "body_posture": "sitting",
    "measurement_location": "left upper arm",
    [...]
}
```





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IEEE P1752

- IEEE P1752 Open Mobile Data Working Group
- PAR submitted December 2016, approved February 2017
- First WG call on February 5, 2018
- Slides and minutes of all the calls on the public website https://sagroups.ieee.org/1752/

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- **Purpose:** The purpose of this Working Group is to provide standard semantics to enable meaningful description, exchange, sharing, and use of mobile health data across a wide spectrum of use cases addressing consumer health, biomedical research, and clinical care needs. These standard semantics will be in the form of common data and metadata schemas...
- **Main work:** 1) define priority areas for schema development; 2) prepare the draft standard for balloting; and 3) promote and support ongoing community use, contribution, and refinement of the schemas.
- Working group website: https://sagroups.ieee.org/1752/

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Preparatory work and subgroups

- Several surveys to learn about our WG and gather priorities
- Choice of topics to focus on based on interest and expertise:
  - Sleep measures
  - Physical activity
  - Minimum metadata
- Discussions at the WG level on broader topics
- Pilot project for IEEE OpenSource

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IEEE Std.1752.1

- IEEE Std 1752.1 Standard for Mobile Health Data: Representations of Metadata, Sleep and Physical Activity Measures (published 2021)
- Standard document + schemas in the IEEE Opensource repository https://opensource.ieee.org/omh/1752
- Repository includes sample data

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Standard Schemas

- In JSON Schema format
- Each data point or data series includes
  - header (UUID, body schema ID, creation date-time, ...)
  - body (typically a measure, i.e., instance of a measure schema)

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IEEE 1752.1 Schemas

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In JSON Schema

Approved IEEE standard 1752.1

Name	Last commit	Last update
..		
environment	Resolve "Create version 1.0 for publication"	1 month ago
metadata	Resolve "Create version 1.0 for publication"	1 month ago
physical_activity	Resolve "Create version 1.0 for publication"	1 month ago
sleep	Resolve "Create version 1.0 for publication"	1 month ago
survey	Resolve "Create version 1.0 for publication"	1 month ago
utility	Resolve "Create version 1.0 for publication"	1 month ago
README.md	Resolve "Create version 1.0 for publication"	1 month ago

README.md

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IEEE 1752.1 Schemas

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JSON Schema header structures
standardized minimum metadata

Name	Last commit	Last update
..		
environment	Resolve "Create version 1.0 for publication"	1 month ago
metadata	Resolve "Create version 1.0 for publication"	1 month ago
physical_activity	Resolve "Create version 1.0 for publication"	1 month ago
sleep	Resolve "Create version 1.0 for publication"	1 month ago
survey	Resolve "Create version 1.0 for publication"	1 month ago
utility	Resolve "Create version 1.0 for publication"	1 month ago
README.md	Resolve "Create version 1.0 for publication"	1 month ago

README.md

Name
..
data-point-1.0.json
data-series-1.0.json
header-1.0.json
schema-id-1.0.json

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IEEE 1752.1 Sample Data

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Sample data as supporting documentation

Name	Last commit	Last update
..		
environment	fixed indentation for all sample data files	1 year ago
metadata	fixed indentation for all sample data files	1 year ago
physical_activity	fixed indentation for all sample data files	1 year ago
sleep	Update apnea-hypopnea-index-sample-data-two.json	8 months ago
survey	Update Example Survey-Sleep related habits.md	8 months ago
utility	fixed indentation for all sample data files	1 year ago
README.md	Using Mermaid markdown to display the repository structure instead o...	1 year ago

README.md

Name
..
data-point-sample-data-ambient-temp.j...
data-point-sample-data-phys-activity.json
data-series-sample-series-ambient-tem...
header-sample-data.json
schema-id-sample-data.json

Name
..
physical-activity-sample-data-jumping-ro...
physical-activity-sample-data-running-sta...
physical-activity-sample-data-running.json
physical-activity-sample-data-sedentary.j...
physical-activity-sample-data-swimming-l...
physical-activity-sample-data-swimming-...
physical-activity-sample-data-walking.json
physical-activity-sample-data-wheelchair-...

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Categories of Metadata

Datapoint (may be observed or computed)	Description of the datapoint itself
Source	From what sensor(s) did the datapoint come?
Acquisition / Processing	How was the datapoint acquired? processed?
Attribution	What app or product provided this datapoint?
Privacy	Who can access, when, why, for what

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IEEE 1752.1 Example Schema

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Schema: a template for instance data

ambient-temperature-1.0.json 1.22 KB

Edit Web IDE

```
{
    "$schema": "http://json-schema.org/draft-07/schema#",
    "$id": "https://w3id.org/ieee/ieee-1752-schema/ambient-temperature.json",
    "title": "Ambient Temperature",
    "description": "This schema represents the ambient temperature.",
    "type": "object",
    "definitions": {
        "temperature_unit_value": {
            "$ref": "temperature-unit-value-1.0.json"
        },
        "time_frame": {
            "$ref": "time-frame-1.0.json"
        },
        "descriptive_statistic": {
            "$ref": "descriptive-statistic-1.0.json"
        }
    },
    "properties": {
        "ambient_temperature": {
            "$ref": "#/definitions/temperature_unit_value"
        },
        "effective_time_frame": {
            "description": "The date-time at which, or time interval during which the measurement is asserted as being valid.",
            "$ref": "#/definitions/time_frame"
        },
        "descriptive_statistic": {
            "description": "The descriptive statistic of a set of measurements (e.g., average, maximum) within the specified time frame.",
            "$ref": "#/definitions/descriptive_statistic"
        }
    },
    "required": [
        "ambient_temperature",
        "effective_time_frame"
    ]
}
```

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IEEE 1752.1 Sample Data

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Sample instance of ambient temperature (header and body)

data-point-sample-data-ambient-temp.json 905 Bytes

```
{
    "header": {
        "uuid": "123e4567-e89b-12d3-a456-426655440000",
        "source_creation_date_time": "2013-02-05T07:25:00+01:00",
        "schema_id": {
            "namespace": "ieee",
            "name": "ambient-temperature",
            "version": "1.0"
        },
        "modality": "sensed",
        "acquisition_rate": {
            "value": 0.05,
            "unit": "Hz"
        },
        "external_datasheets": [
            {
                "datasheet_reference": "iri-of-some-ambient-thermometer"
            },
            {
                "datasheet_type": "study",
                "datasheet_reference": "iri-of-some-study-protocol"
            }
        ]
    },
    "body": {
        "ambient_temperature": {
            "value": 19,
            "unit": "C"
        },
        "effective_time_frame": {
            "date_time": "2013-02-05T07:25:00+01:00"
        }
    }
}
```

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Sample instance of physical activity (body only)

physical-activity-sample-data-running.json 1.08 KB


```
{
    "description": "the running [illegible]ode that occurred on March 29, 2019 [illegible]
    "activity_name": "Running",
    "effective_time_frame": {
        "time_interval": {
            "start_date_time": "2019-03-29T08:26:03Z",
            "end_date_time": "2019-03-29T09:14:41Z"
        }
    },
    "distance": {
        "value": 7.45,
        "unit": "km"
    },
    "duration": {
        "value": 45.5,
        "unit": "min"
    },
    "kcal_burned": {
        "value": 383,
        "unit": "kcal"
    },
    "average_cadence": {
        "value": 184,
        "unit": "steps/min"
    },
    "average_speed": {
        "value": 9.7,
        "unit": "km/h"
    },
    "cumulative_elevation_gain": {
        "value": 108,
        "unit": "m"
    },
    "duration_moderate_activity": {
        "value": 4.5,
        "unit": "min"
    },
    "duration_vigorous_activity": {
        "value": 41,
        "unit": "min"
    }
}
```


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IEEE P1752.2

- P1752 → family of standards
- P1752.2 Standard for Mobile Health Data: Representation of Cardiovascular, Respiratory, and Metabolic Measures (current work, started on July 6, 2021)
  - Cardio-respiratory measures' subgroup (blood pressure, heart rate, respiratory rate, heart rate variability, etc.)
  - Metabolic measures' subgroup (blood glucose, body weight)

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Summary

- Standardizing wearables' data and metadata promotes data aggregation
- Clean syntax, clear semantics optimized for mHealth use cases
  - IEEE 1752.1 standard approved
- Expand schemas to additional clinical domains, further develop common metadata approach
  - IEEE P1752.2 in progress
- Learned a lot by going through the IEEE standard development process

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Thank You

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