Mobile Computing

Sensors

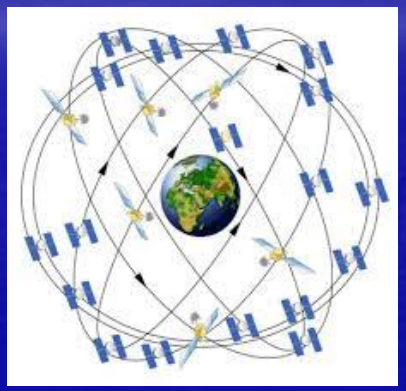
Location

- **Where in the world am I ?**
  - **Earth surface point**
    - **Latitude and longitude (º)**
    - **Altitude (m)**
    - **Accuracy (m)**

- **Status of movement**
  - **Speed (m/s)**
  - **Bearing (º from North)**

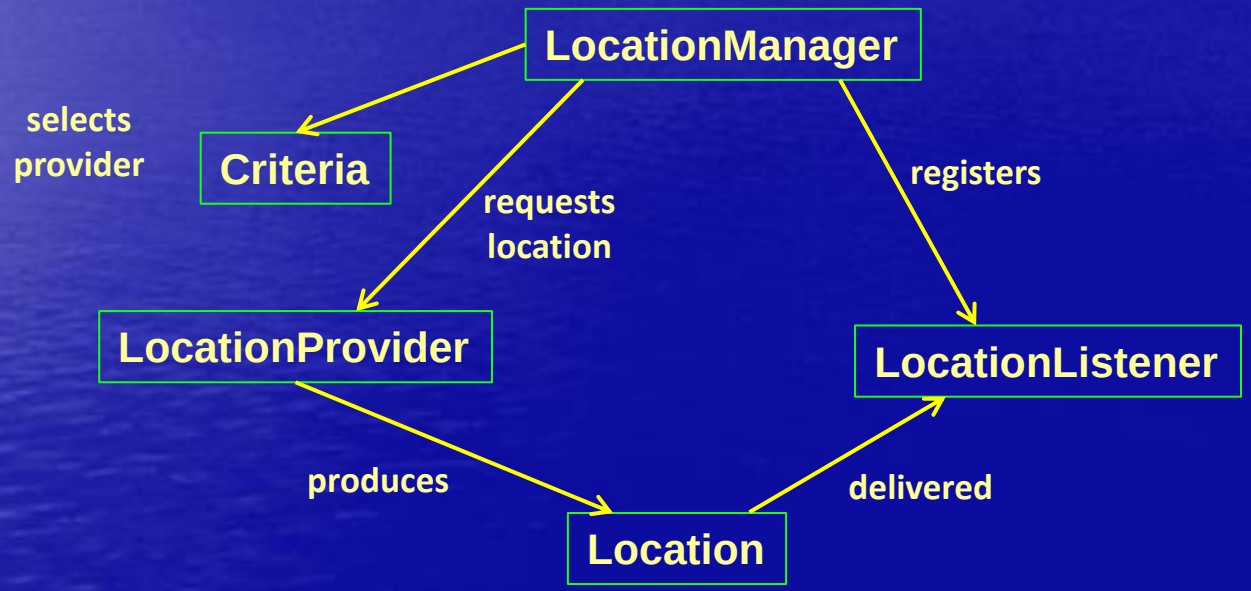
Location providers

- A device may have several providers
  - Location can be obtained directly from satellites (GPS)
  - Or can be derived from
    - Wi-fi access points information
    - Mobile communication towers location
- They are condensed in the providers
  - GPS_PROVIDER (“gps”)
  - NETWORK_PROVIDER (“network”)
  - Also usually exists a PASSIVE_PROVIDER (another app)
- GPS
  - Accurate, more info, more power consumption, more delay, needs line of sight to satellites (weak signals)
- Network
  - Less accurate, less consumption, less delay, interiors



Android classes and permissions

- Android manifest must declare permissions
  - ACCESS_COURSE_LOCATION and/or
  - ACCESS_FINE_LOCATION



LocationListener

Interface declaring methods (callbacks) where information is delivered after requesting a location

```
public interface LocationListener {
    void onLocationChanged(Location location);
    void onProviderDisabled(String provider);
    void onProviderEnabled(String provider);
    void onStatusChanged(String provider, int status, Bundle extras);
}
```

not called in API 29

OUT_OF_SERVICE
TEMPORARILY_UNAVAILABLE
AVAILABLE

satellites:
nr. of satellites in gps

LocationManager

System service for requesting locations and selecting a provider

Obtained in an Activity:

```
locationManager = (LocationManager) getSystemService(LOCATION_SERVICE);
```

Locations should be requested only when the activity is active and cancelled when it stops being in foreground. So requests can be done in the onResume() callback of the activity, from the LocationManager object, with:

```
requestLocationUpdates(long minTime, float minDistance, Criteria criteria,
                       LocationListener listener, Looper looper)
```

minimum time or distance for a new location

selection of a provider

class implementing the listener

null for the current thread

(there are more overrides)

In onPause() we should cancel the request and stop the provider:

```
removeUpdates(LocationListener listener)
```

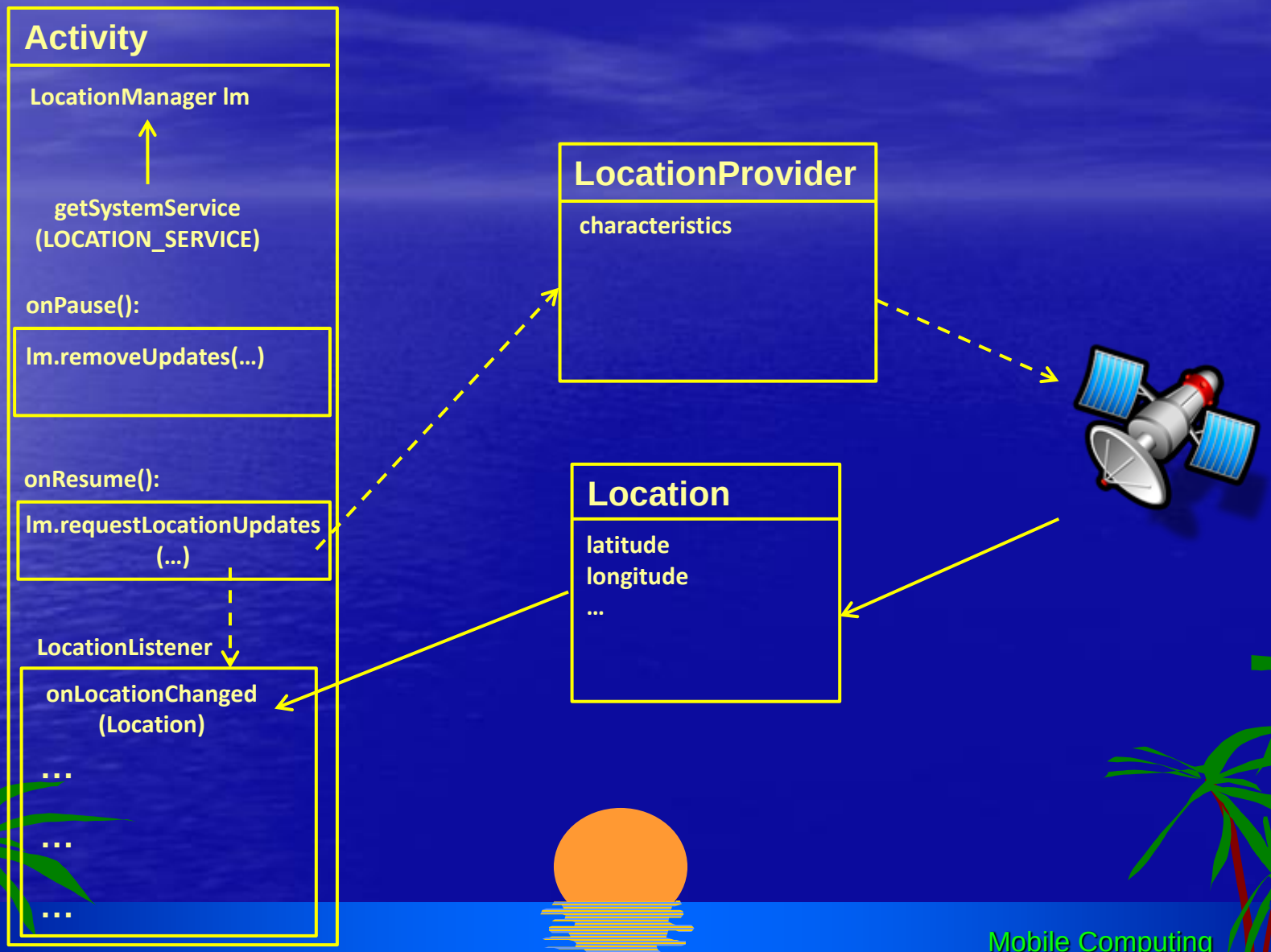
It is also possible to request a single location or an alert of proximity to a given location expressed in latitude or longitude.

requestSingleUpdate(...) and addProximityAlert(...)

Location

- Locations are delivered to LocationListener
  - They bring latitude and longitude
  - The provider that has generated it
  - The time it was generated
  - If the provider had the information it can also contain
    - The altitude of the location
    - The accuracy of the location
    - The bearing if the device is moving
    - The speed also if it is moving
    - The number of satellites used to obtain the location
  - Some convenience methods allow
    - To know the bearing from this location to another (geodesic)
    - The distance between locations (along a geodesic)
    - Obtain a convenient String representation

Receiving location information



Sensors

- Android has support for several sensors and a common API to get their measurements
  - Sensors available include
    - movement sensors
    - orientation sensors
    - environment sensors
  - Sensors can be divided into
    - physical sensors giving actual measurements of some quantity
    - synthesized sensors fusing and processing the measurements of other physical sensors to calculate another quantity
  - Sensors can be characterized by
    - Range and resolution (minimum, maximum and step value)
    - Rate of measurement (nr. of measurements per time unit)
    - power consumption

Sensor types supported

Android defines a constant for each of the sensor types supported by the operating system, in the Sensor class. But each device may have only a few of those sensors.

Defined types: **physical**

movement:
- TYPE_ACCELEROMETER (3D)
- TYPE_GYROSCOPE (3D)

orientation:
- TYPE_MAGNETIC_FIELD (3D)

environment:
- TYPE_AMBIENT_TEMPERATURE
- TYPE_LIGHT
- TYPE_PRESSURE
- TYPE_PROXIMITY
- TYPE_RELATIVE_HUMIDITY

synthetized

- TYPE_GRAVITY (3D)
- TYPE_LINEAR_ACCELERATION (3D)
- TYPE_ORIENTATION (3D)
- TYPE_ROTATION_VECTOR (3 or 4D)
- TYPE_SIGNIFICANT_MOTION (Trigger)

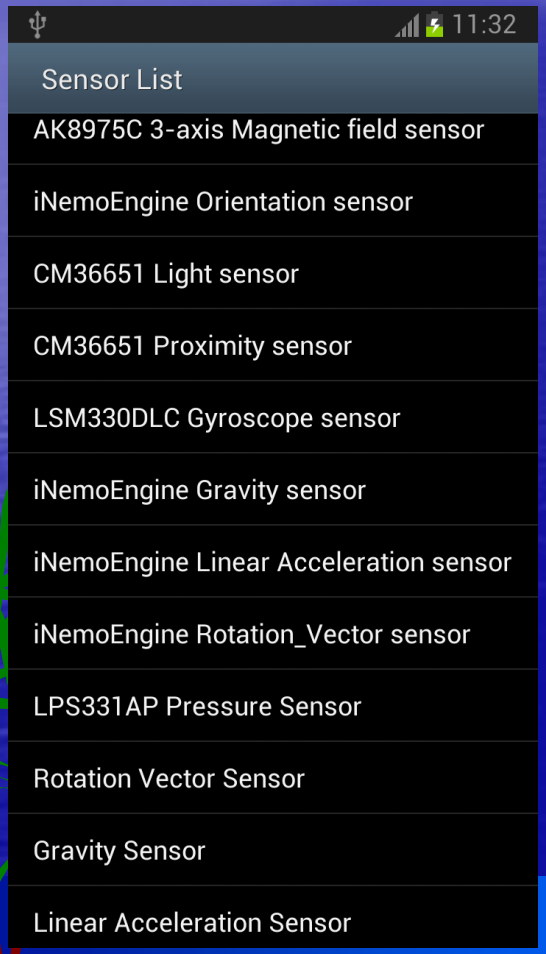
For getting a list of all sensors present on a device, there is the constant:

TYPE_ALL

List of sensors are acquired from the SensorManager calling getSensorList(type)

Sensors on a device

It's possible for a device to have more than one sensor of the same type. It's uncommon for physical sensors, but can happen with synthesized sensors (more than one implementation).

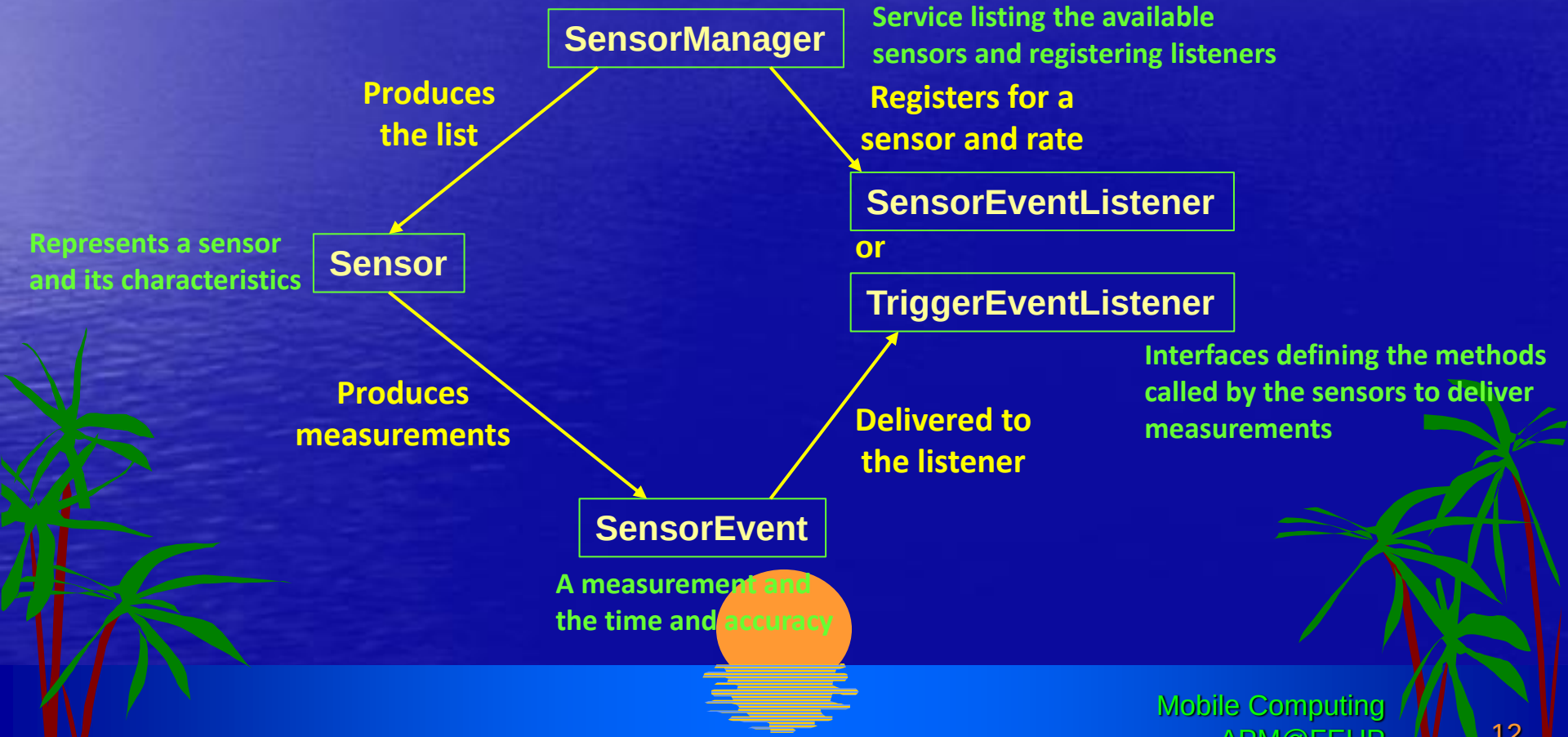


When an application requests the sensors of a certain type (with getSensorList(type)), the system returns an array of sensors.

Sensor API classes

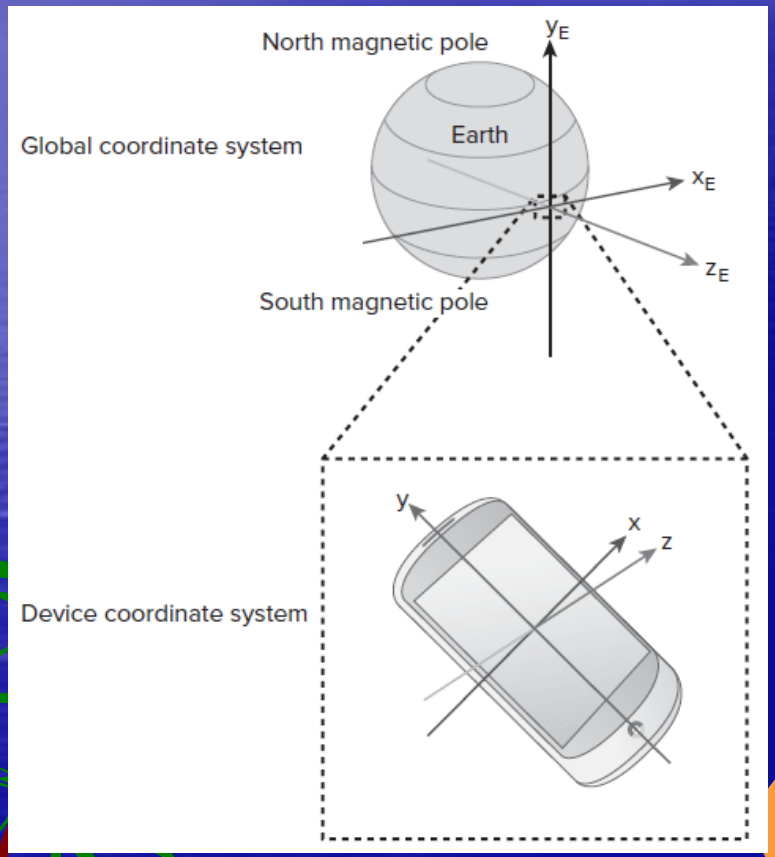
The SensorManager is the starting point and can be obtained from the Activity with:

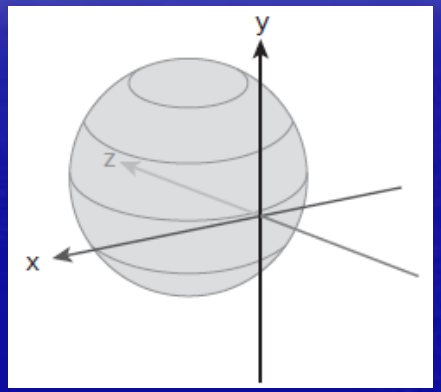
```
(SensorManager) getSystemService(SENSOR_SERVICE)
```



Movement and orientation

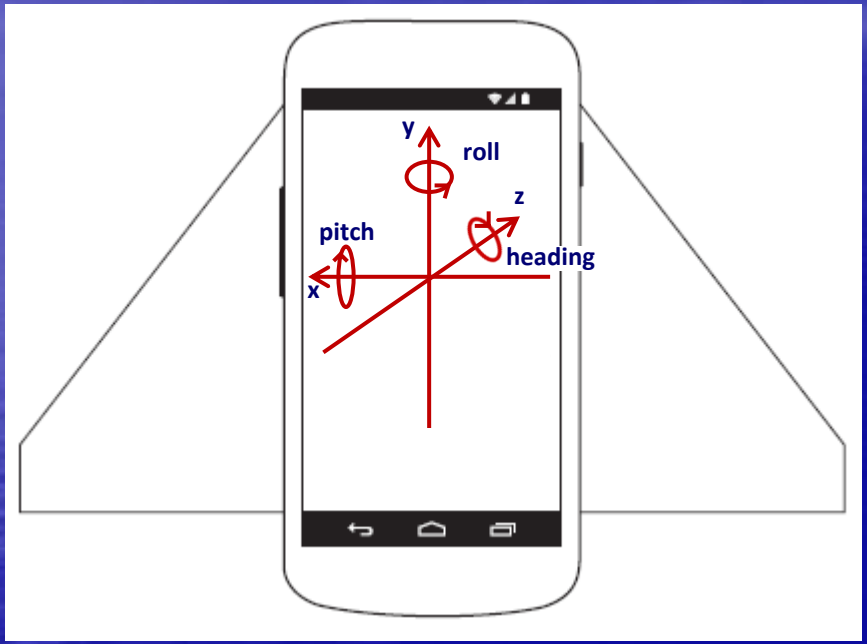
Movement quantities are presented in the device coordinate system. Orientation measures are in the earth coordinate system (except TYPE_ORIENTATION and getOrientation() measurements).





TYPE_ORIENTATION and getOrientation() measurements earth coordinate system

Orientation measurements



Heading – 0º to 360º

Pitch – -180º to 180º

Roll – -90º to 90º

SensorManager

- Activities get it from the system
- It knows the sensors available on the device
  - We can get a list of all or of a single type of sensors
  - It's possible to have more than one sensor of a given type (specially of fusion/synthesized sensors)
- It can register the SensorEventListener for one or more sensors
- It defines some measure transformation methods
  - getRotationMatrixFromVector()
    - uses the ROTATION_VECTOR sensor and computes a rotation matrix
  - getRotationMatrix()
    - computes Inclination and Rotation matrices from gravity and geomagnetic fields
  - getInclination() (from the Inclination matrix)
  - getOrientation() (from the Rotation matrix)
  - getAltitude()
    - From the atmospheric pressure here and at sea level

SensorEventListener

Interface declaring methods (callbacks) where measurements are delivered after registering it for a sensor.
Measurements are represented by an instance of SensorEvent

```
public interface SensorEventListener {
    void onSensorChanged(SensorEvent event);
    void onAccuracyChanged(Sensor sensor, int accuracy);
}
```

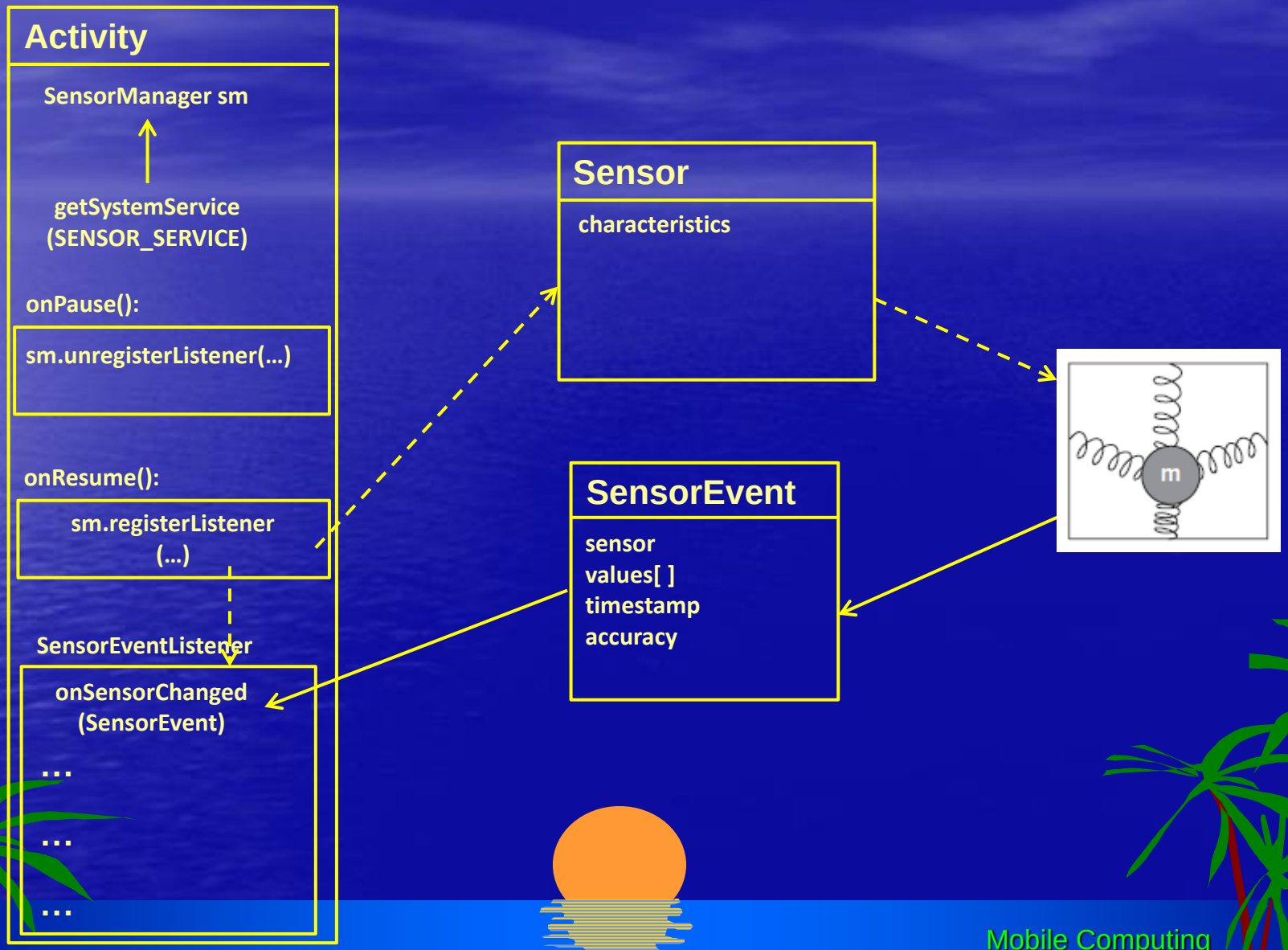
sensor
values[ ]
timestamp
accuracy

SENSOR_STATUS_ACCURACY_HIGH
SENSOR_STATUS_ACCURARY_MEDIUM
SENSOR_STATUS_ACCURACY_LOW
SENSOR_STATUS_ACCURARY_UNRELIABLE

For sensors producing an event at a time (like the SIGNIFICANT_MOTION detector) use the abstract class:

```
public abstract class TriggerEventListener {
    public void onTrigger(TriggerEvent event);
}
```

Receiving sensor measurements



Noise and signal processing

- Many sensors produce several kinds of noise
  - High frequency variations with significant amplitudes
  - Low frequency deviations (drifts)
- Some simple frequency domain filters are useful
  - Low pass filters
    - Weighted smoothing
    - Simple moving average
    - Simple moving median
  - High pass filters
    - Inverse low pass filter
  - Band pass filters and its inverse
    - Simultaneous low and high pass
  - Kalman filters