

Duking It Out at the Smartphone Mobile Mapping App Corral: Apple, Google, Windows and the Competition

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([Best Paper Award, Expanded Version](#)).

Historical Background

- Explosive growth of Internet coupled with the increasing use of location-enabled devices such as smart phones has led to an increasing awareness of the importance of location information
- Traditionally presented with a map
 - Aesthetically pleasing and familiar to their users
 - Often at the expense of accuracy
 - But acceptable due to conformance with commonly held beliefs
 - E.g., that the Earth was flat in pre-Columbus times
 - Winding roads with screw-like symbols where number of turns in symbol has nothing to do with the number of switchbacks
- Maps used not only to present information but also to store and access it
- Maps drawn by cartographers/artists
- Advent of computers drastically shortened time needed to make a map
- Quantities of each map produced reduced dramatically and often at will
- Presented in units of one rather than in groups as an atlas of maps
- Web-based queries mean no hesitation in seeking a map
- Search engines return a map as part of response

Location Specification

- Explicit via geometry (latitude-longitude pairs of numbers)
 - Users don't know them in this way or used to communicate in this way
- Accustomed to textual specification
 - Easy to communicate on smartphone devices with soft keyboard
 - Verbally and can be captured by speech recognition (e.g., Siri)
 - Like a polymorphic type
 - One size fits all
 - "Los Angeles" can be interpreted as a point or an area and user need not be concerned about it
 - Drawback is ambiguity
 - Is "London" reference a person or a location? (toponym recognition)
 - If "London" is a location, which of many? (toponym resolution)
 - Geotagging: Conversion from a textual to a geometric specification
- Implicit specification
 - IP address of user's computing platform
 - Embedded GPS capability providing user's physical location
- Map coupled with a pointing device like a mouse
- Map coupled with a touch or gesturing interface

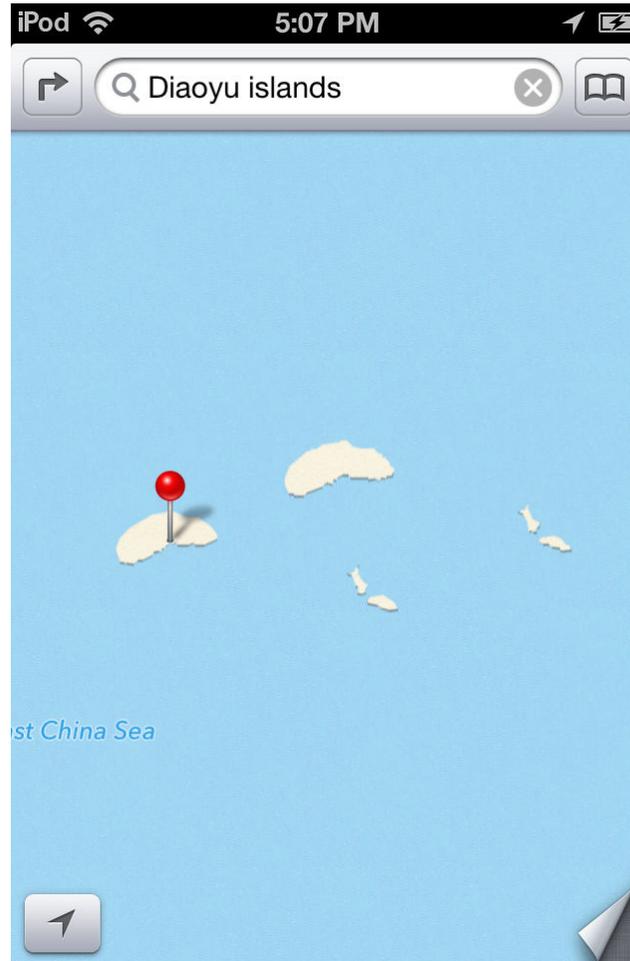
Location Specification via a Gesturing Interface

- Combines implicit and explicit specification for approximate specification
- Map, coupled with ability to pan and to vary the zoom level at which the world is viewed, provides an inherent granularity to the location specification process which facilitates this approximate specification
- Act of pointing at a location (i.e., by the appropriate positioning of a pointing device with the aid of panning) and making the interpretation of the precision of this positioning specification dependent on the zoom level is equivalent to permitting the use of spatial synonyms
 - Hallmarks of approximate specifications
 - Enables search for data when not exactly sure of what we are seeking
 - Ex: Seek a “Rock Concert in Manhattan”
 - “Rock Concerts” in “Harlem” or “New York City” are good answers when none in Manhattan” as correspond to approximate synonyms: “Harlem” by proximity, and “New York City” by containing Manhattan
- Result: no longer need to know exact name or position of desired location
- Gesturing interface serves as an implicit access structure to the data accomplished with direct manipulation
- An index is still required whose access is achieved by software that translates the screen coordinates to the ones used by the index

Maps on Smartphones

- De facto practice: when operations (invariably queries) involve any location information, the query result is presented using a map, and increasingly so is the formulation of the query
 - wide range of applications
 - wide range of sources for maps
- Drawback: maps are not necessarily produced in a manner consistent with traditional concerns for:
 - Trade-offs between accuracy, aesthetics, and completeness AND
 - Generally accepted cartographic principles
- Satisfaction with increase in capabilities inhibited expression of dissatisfaction with drawbacks
 - Inhibitions abandoned with introduction of iPhone 5 and iOS6 using a mapping App with Apple's Map data instead of Google's map data
 - Use of maps on smartphone is not the traditional passive one as in the case of atlases that are browsed leisurely
 - Instead, maps are used in an active manner as a tool for tasks such as navigation and location finding where accuracy is paramount
 - Issues of data quality and lack of quality assurance policies and protocols became very apparent

iOS6 Map Error - Duplicate Islands



Diaoyu/Senkaku Islands

- Old iOS6 Apple Maps shows disputed Diaoyu (Chinese name) and Senkaku (Japanese name) Islands twice: once per claiming owner country probably due to having different names in the two languages
- Currently, both specifications lead to same location

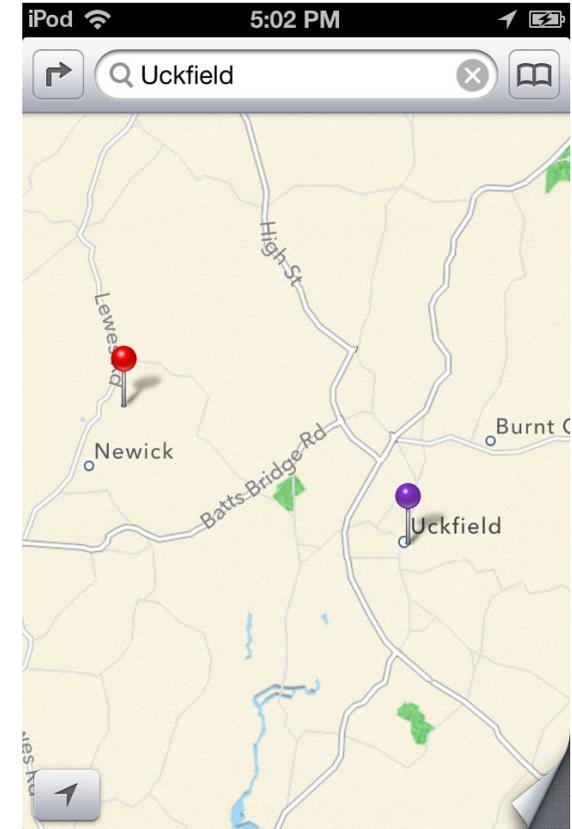
iOS6 Location Errors



Stockholm, Sweden



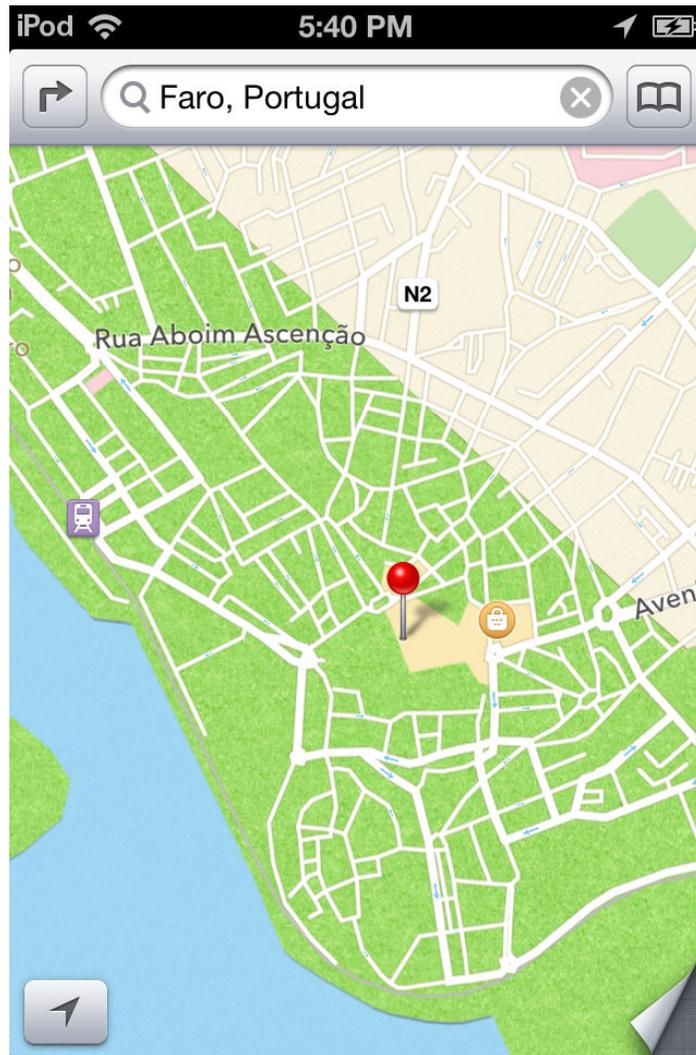
Washington Monument



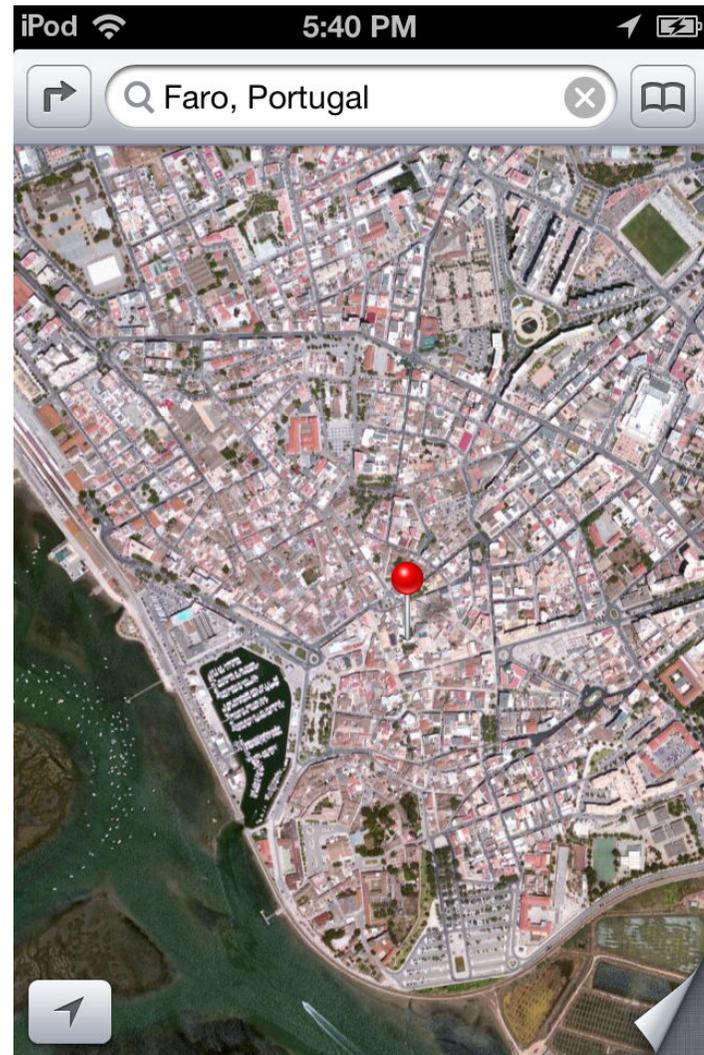
Uckfield, UK

- Initially Stockholm, Washington Monument, and Uckfield in UK were mislocated
- All corrected in latest versions of iOS6 and iOS7

iOS6 Map vs Reality - Faro, Portugal



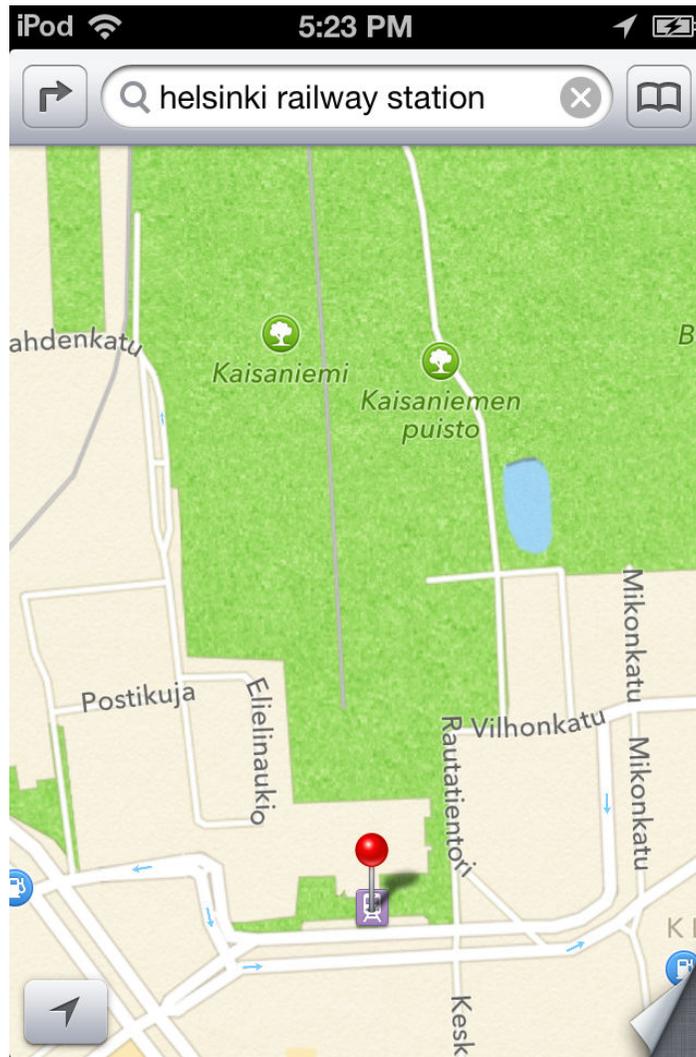
Map



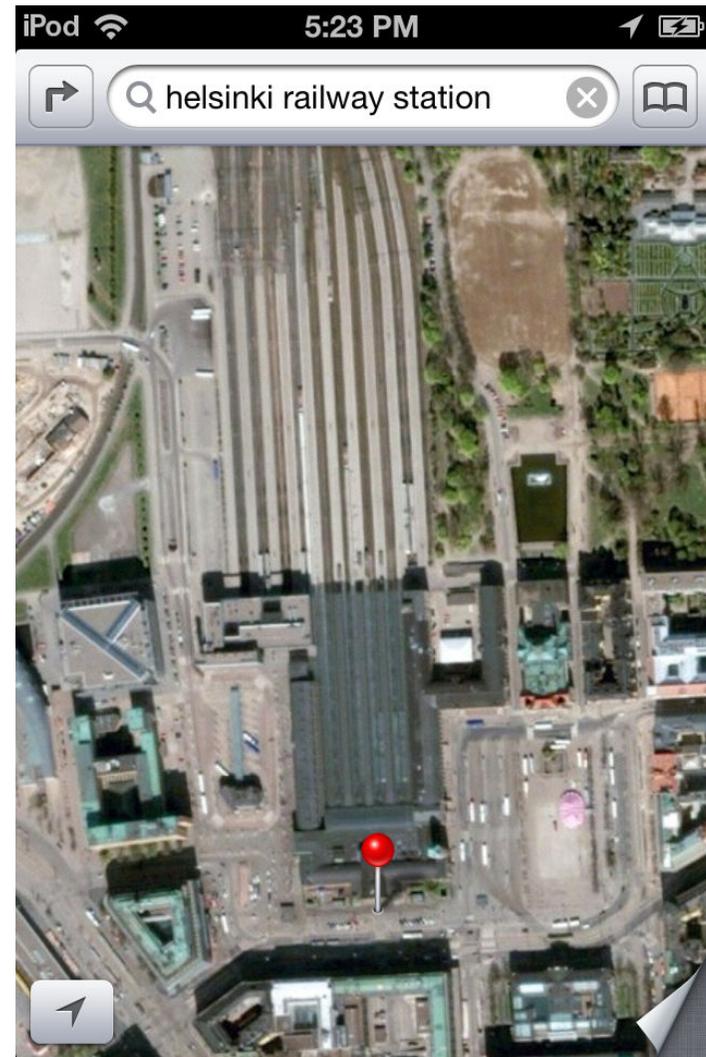
Satellite

- Entire city appears as a park including the harbor

iOS6 Map vs Reality - Helsinki Central Railway, Finland



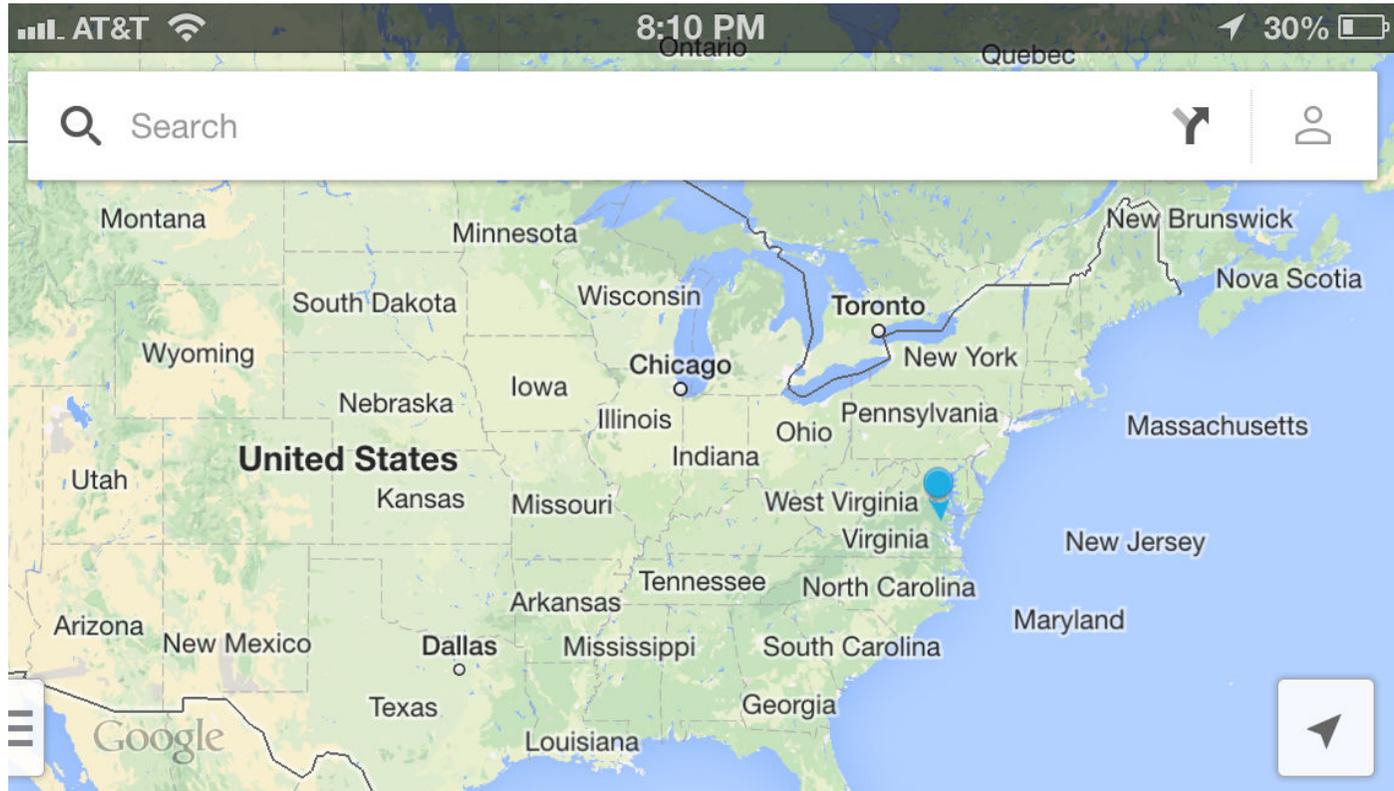
Map



Satellite

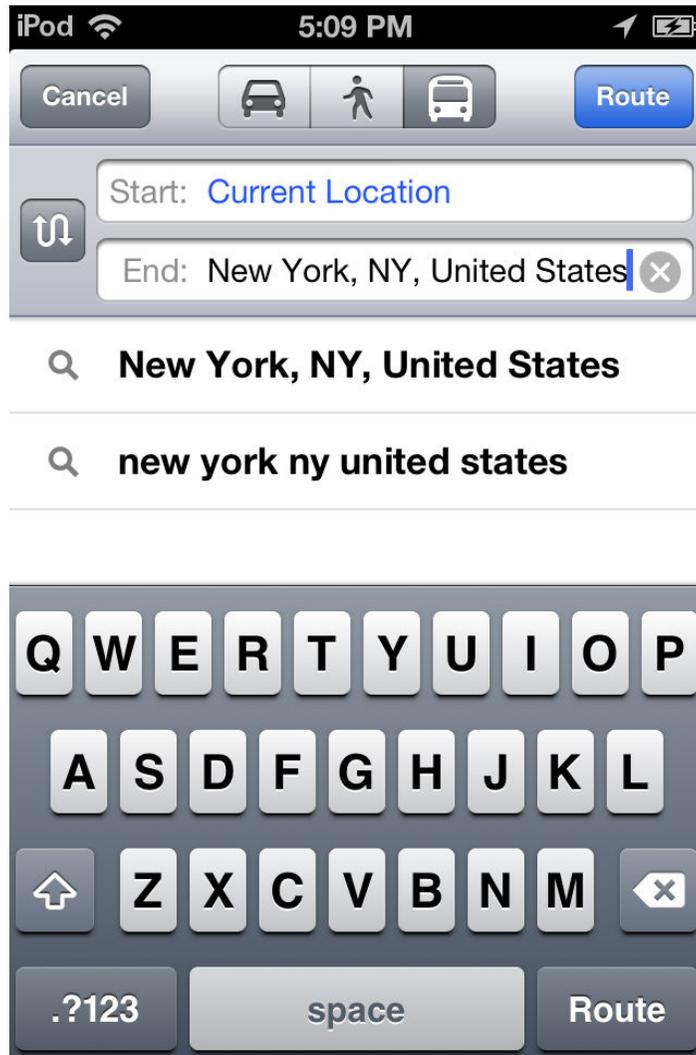
- Entire train station (satellite image) appears as a park

Google Maps Apps Also Have Errors



- iOS Google Maps and Android Apps place Maryland, New Jersey, and Massachusetts erroneously in the Atlantic Ocean

iOS6 Directions Missing Public Transit



Public Transit Selected

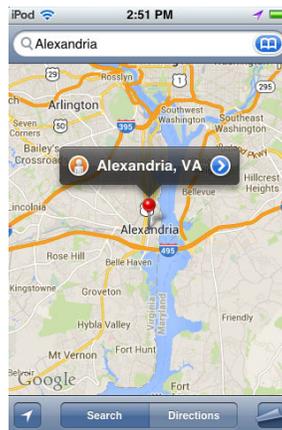


Redirected to Apps

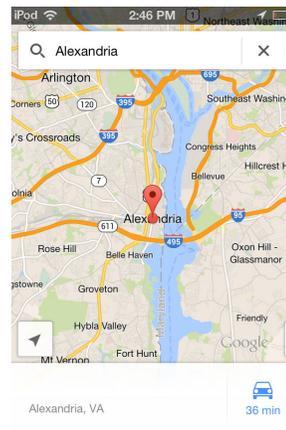
- Public transit instructions send you to apps in the App Store rather than provide the directions explicitly

Other Shortcomings

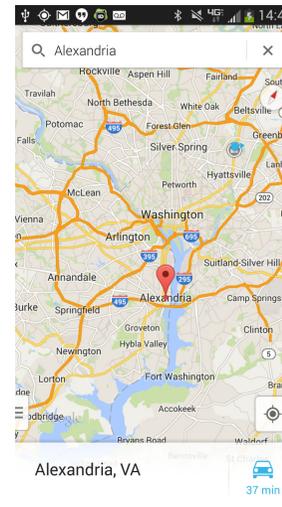
- Fewer points of interest on iOS6 that are not shops or eating places which some attribute to reliance on data from Yelp and Trip Advisor
- No offline navigation in iOS6/7 (also no in all Google Maps Apps)
 - Yes where Nokia HERE Maps are used (Nokia Maps App and WP)
- For ambiguous textually-specified locations, all Google Maps Apps usually return interpretation closest to query poser's location, while iOS6 and iOS7 return the most likely interpretation (often based on population)
 - Not always so for newspapers where audience knowledge is the key
 - Ex: Looking for "Alexandria" when in College Park, MD



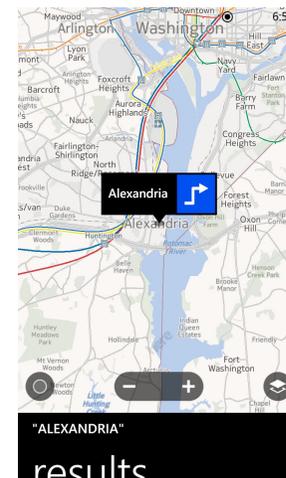
iOS5: VA



iOS Ggl: VA



Android: VA



WP: VA



iOS6/7: Egypt

- But all place Damascus in Syria even when in College Park, MD

Comparison of Desirable Mapping Platform Properties

Features	Mapping Applications										
	A6	A7	A5	GA	GI	B	NK	WP	MQ	OSM	ESRI
Panning C	×	×	✓	✓	✓	✓	✓	×	✓	✓	✓
Zoom C	×	×	✓	✓	✓	✓	✓	×	✓	✓	<i>P</i>
No Overlaps	✓	✓	✓	✓	✓	<i>P</i>	✓	✓	✓	×	✓
Hierarchical C	×	×	<i>P</i>	<i>P</i>	<i>P</i>	✓	<i>P</i>	×	×	✓	×
Sibling C	×	×	✓	×	×	×	×	×	×	✓	×
H Wraparound	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
V Wraparound	×	×	×	×	×	×	✓	×	✓	×	×
Full Zoom Out	<i>P</i>	<i>P</i>	✓	×	<i>P</i>	✓	×	✓	×	✓	✓

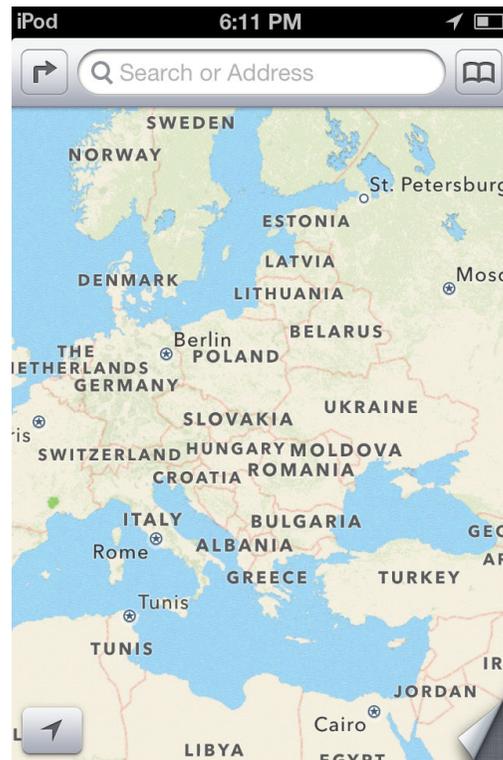
- C="consistency" P="partially holding"
- iOS5 is clearly better now than iOS Google; both better than iOS6/7
- But iOS6/iOS7 uses vector graphics for drawing vs raster graphics for iOS5
 - Vector graphics enables resizing as zooming occurs while raster graphics requires new map tiles to be downloaded as zoom in and out
 - Faster and smoother performance for iOS6 as less data to download
 - Android, Nokia's HERE (WP), and iOS Google Maps are vector-based

Comparison Notes

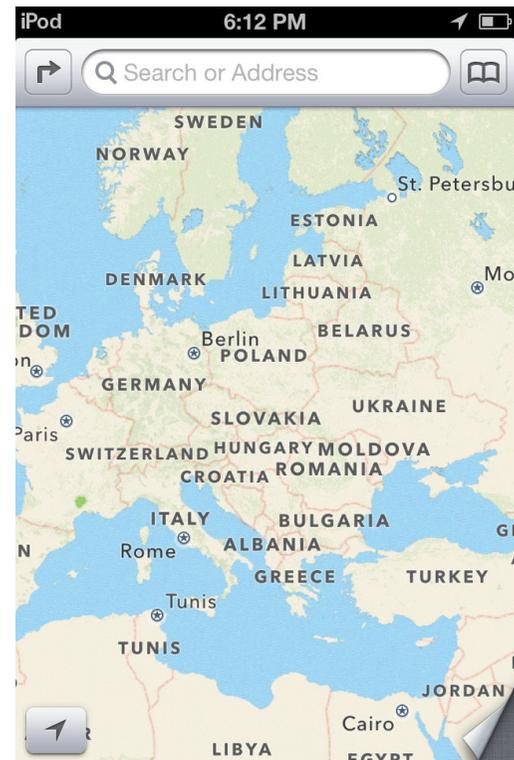
- App details
 - Nokia App is HERE Maps 1.8; MapQuest (version 3.3.1)
 - ESRI is ArcGIS 2.3.2; Maps 6.14.2 on Android 4.1.1
 - OSM (OpenStreetMap) is OpenSeaMap 1.1
 - iOS Google Maps, MapQuest, Nokia Maps, OSM, Bing Maps and ESRI Apps all tested on iOS version 6.1
 - HERE Maps App on Windows Phone 8 (HERE Maps version 3.5.481.8 with map data 8.0.50.116)
- Compare Apps and not mapping APIs
- Mapping API: features in the programming environments on the platforms (iOS5, iOS6, iOS7, iOS, Android, WP) to facilitate building mapping apps
- Just because a feature is unavailable in a mapping API doesn't mean users can't deploy more complex workarounds to obtain such functionality
 - Ex: Horizontal wraparound feature for horizontal panning which is consistent with the Earth being a sphere
 - Available in iOS6 mapping App but not in iOS6 mapping API
 - Impossible in iOS5 in either mapping App or mapping API
 - OK in iOS7 and iOS and Android Google mapping Apps and APIs
 - Feature should be in both the App and API

Panning Consistency (Visibility)

- When panning on map, labels should be consistent and not disappear as long as underlying space is visible and room exist for label
- Does not always hold for iOS6 Apple Maps as can be seen by the disappearance of The Netherlands in the European subcontinent as one pans to the left (achieved by a swipe to the right) out



Original View

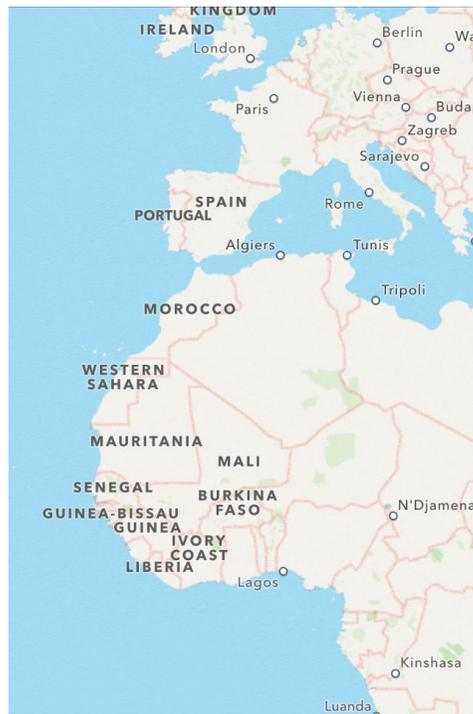


Pan to the Left

- Does not always hold for WP (e.g., Stuttgart in Germany)

Panning Consistency (Type)

- When panning on map, label types should be consistent and not change as pan to another part of the map at the same zoom level
- Does not always hold for iOS7 Apple Maps as can be seen at the maximum zoom level where
 1. Cities for Europe and country names for Africa (sibling inconsistency)
 2. Cities instead of countries for Africa as pan to left (swipe to right)
 3. Countries for Asia as pan further to the left (swipe to right)



City/Country Names



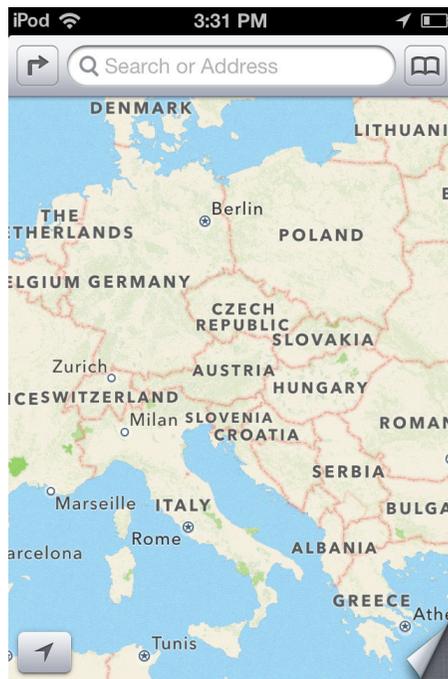
City Names



Country Names Again

Zoom Consistency

- As zoom in, names of places that are displayed continue to be displayed
 - But names of large containers such as “United States” may vanish as the zoom gets very deep
- Holds for all Apps save for iOS6, iOS7, and WP
 - Ex: Slovenia in European subcontinent map (for both iOS6/7 and also Croatia in WP but not shown)



iOS6 Original View



Zoom In



Zoom In Again

- Holds for ESRI although labels change positions at deeper zoom levels

Overlap Avoidance

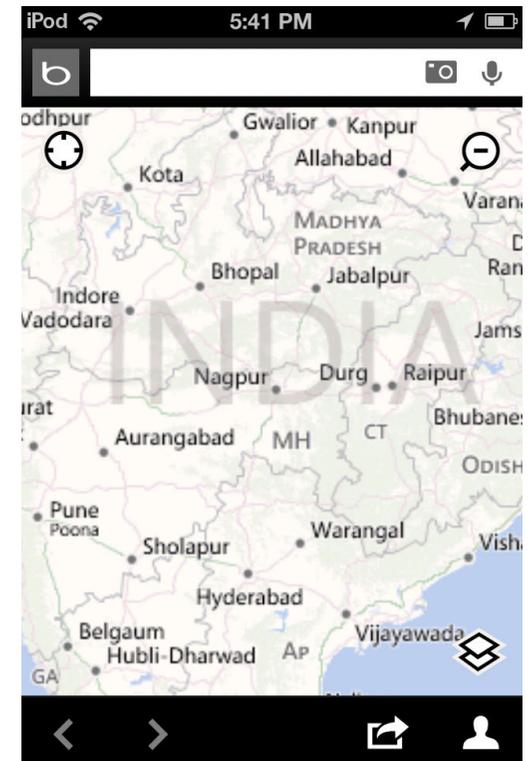
- Place names should not overlap
- Holds for most platforms
 - Not always for OSM as in US map (e.g., Boston and R.I.)
 - Yes for Bing although the watermark style may overlap other names (e.g., India and city names)



OSM



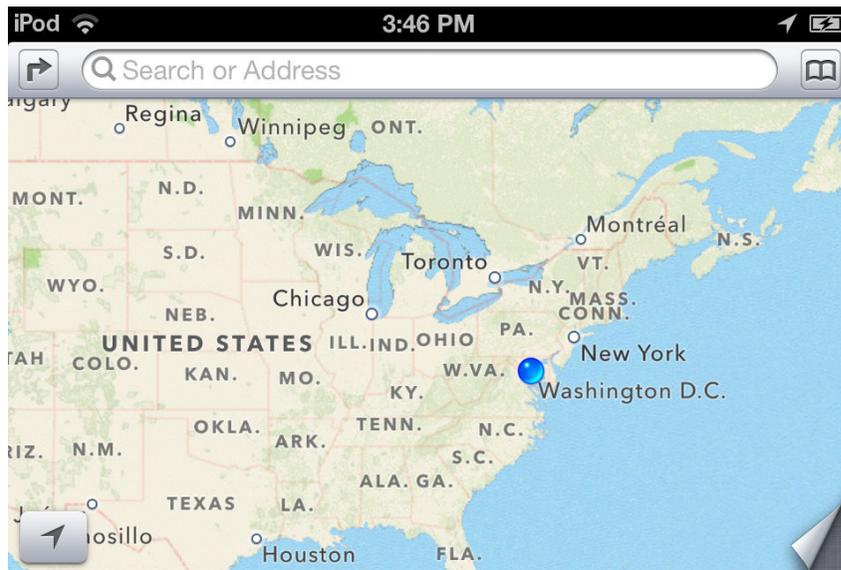
OSM Magnified



Bing

Sibling Consistency

- If display object at a depth of mapping hierarchy, then must also display all visible sibling objects using same type and size of font or symbol
 - Ex: If display abbreviated name of a state, then must display names of remaining visible states in same way using abbreviations
- Only tabulate for state/province names in US/Canada; not for countries within continents
 - Only holds for iOS5 and OSM; not for iOS6 (e.g., Virginia, Maine, Maryland), and iOS7 (e.g., Delaware, New Jersey, Rhode Island)
- No for Android and iOS Google Maps, WP, MapQuest, and ESRI



iOS6



iOS5

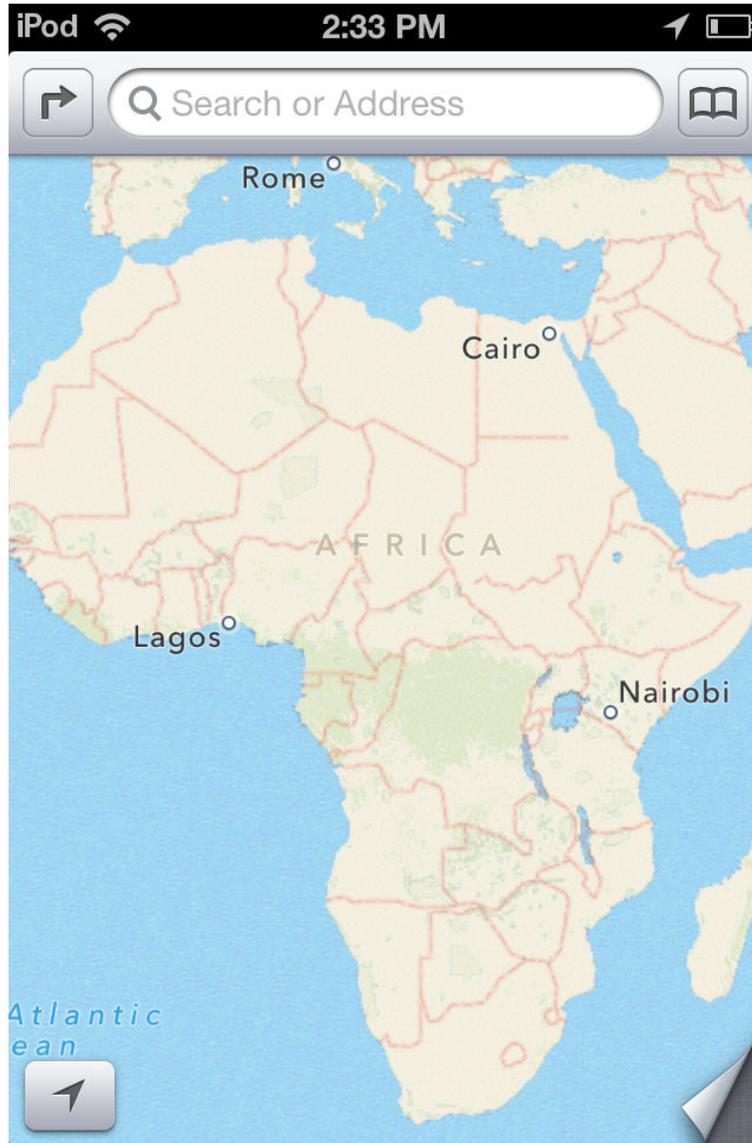
Wraparound

- Enables taking advantage of Earth being a sphere
- Want wraparound capability in all directions
- Horizontal wraparound
 - Useful in neighborhood of Bering Strait so can go between North American and Asian continents
 - Allowed in all but Bing and iOS5 Apps
 - iOS7, Android Google, iOS Google, and WP APIs allow it
 - Curious that iOS6 allows it but the iOS6 API does not
- Vertical wraparound
 - Only in MapQuest and Nokia Apps and not in other Apps or WP
 - Useful for panning around Antarctica and the Arctic
 - Facilitates construction of maps such as the Wizard of New Zealand's map of the world centered in New Zealand
 - None of the APIs (iOS5, iOS6, iOS7, iOS Google, Android Google, WP) allow it

Full Zoom Out

- Enables entire world to be seen on the device display with one view instead of having to pan the map
- Available in full in the iOS5 Google Maps, Bing Maps, and ESRI
 - Only in portrait mode for WP
- Only 25% of the world in Nokia Maps and MapQuest Apps
- 50% of the world in iOS6/7 Apple Maps, iOS Google Maps, and Android Apps
- Same behavior as in the App is available in the API for iOS5 and iOS Google Maps, iOS6/7 Apple Maps, and WP Phone Maps
- API for version 2 of Android Maps allows a slightly larger part of the world to be seen than the Android Maps App

Small Scale Map: Continent Level (Africa): iOS6 iOS5

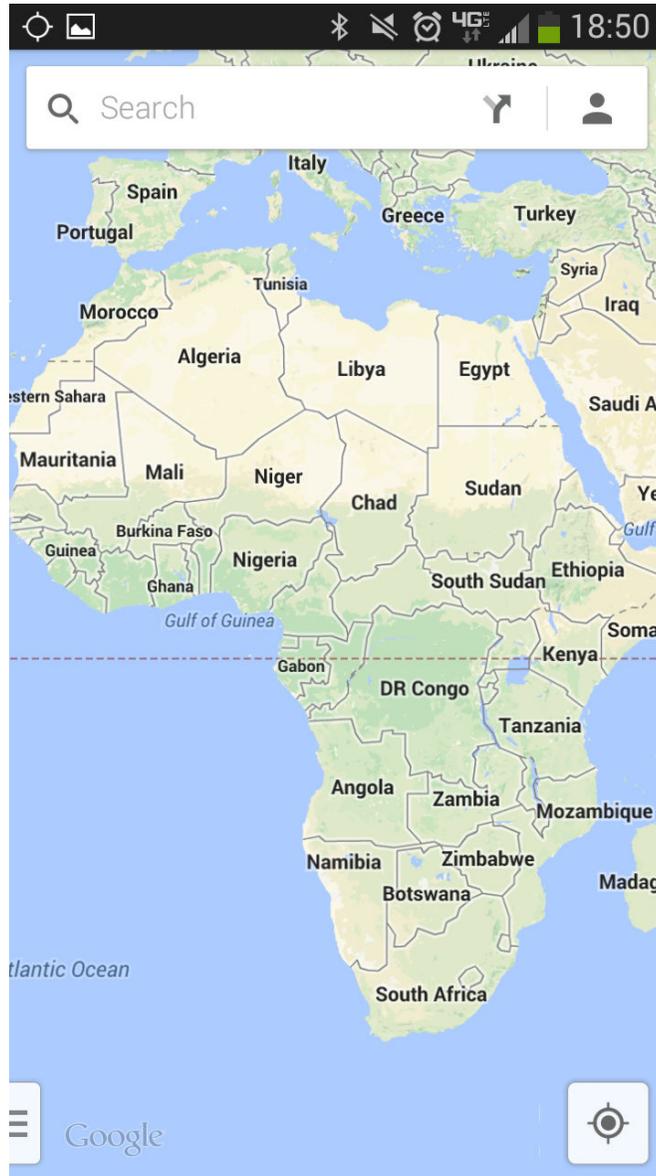


iOS6

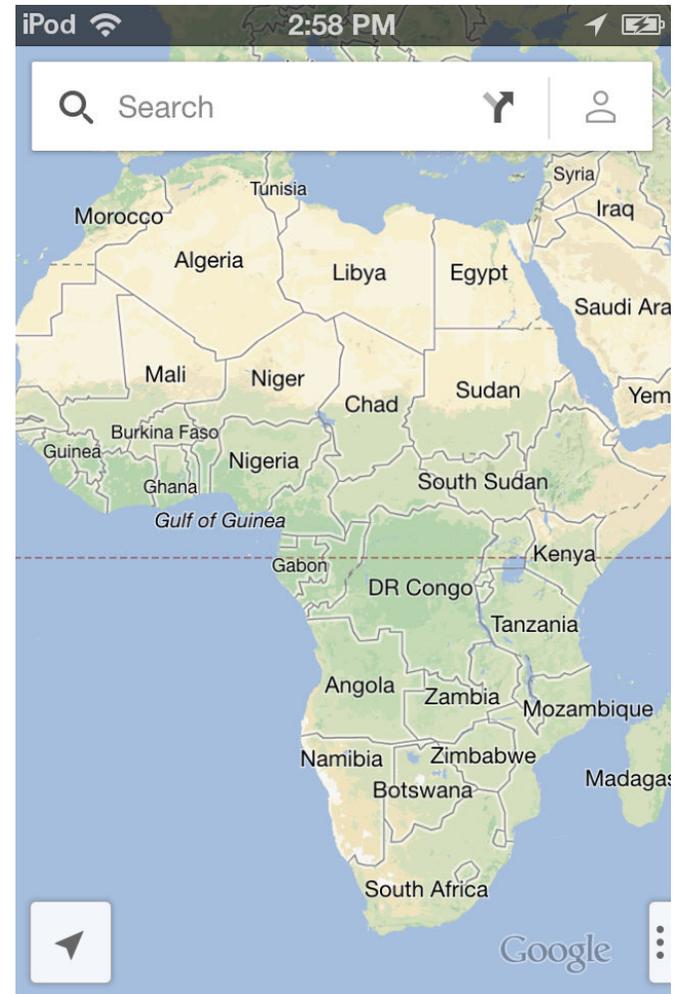


iOS5

Small Scale Map: Continent Level (Africa): Android, iOS Google



Android



iOS Google

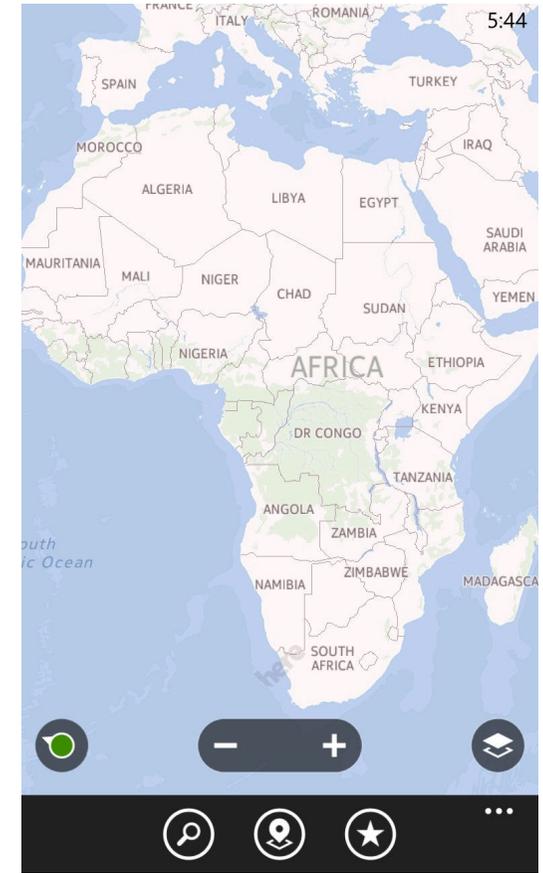
Small Scale Map: Continent Level (Africa): Bing, Nokia, WP



Bing



Nokia

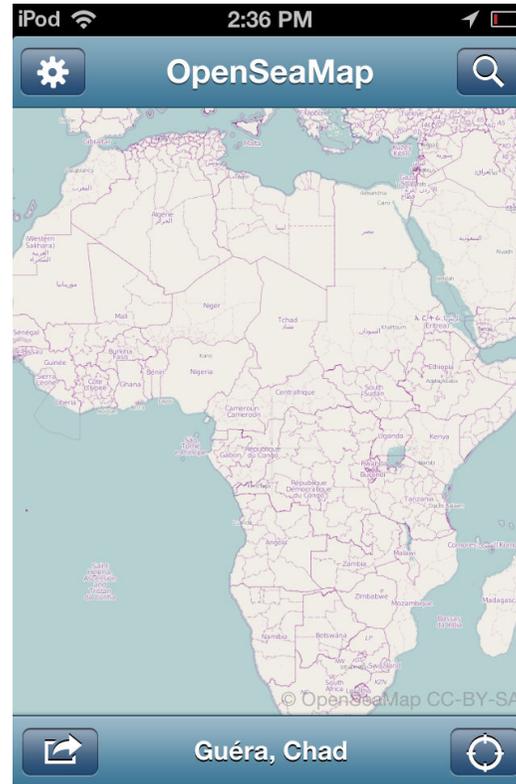


WP

Small Scale Map: Continent Level (Africa): MapQuest, OSM, ESRI



MapQuest



OSM



ESRI

Small Scale Map: Continent Level (Africa): Observations (1)

1. iOS6 Apple Maps: Hierarchical inconsistency as continent (Africa) and cities (Lagos, Cairo, and Nairobi) are labeled but no countries
 - iOS7 Apple Maps is the same except for bold face continent name instead of watermark style in iOS6
2. Google Maps:
 - Partial hierarchical consistency (cities before admin regions China/India)
 - iOS5, Android, and iOS versions of Google Maps differ:
 - Ethiopia, Somalia, Mauritania, and Western Sahara in iOS5 and Android while missing in iOS Google Maps (all miss Eritrea)
 - One line display for multi word labels in Android and iOS Google Maps, while multiple lines in iOS5 (e.g., Burkina Faso)
3. OSM:
 - Too much detail for smartphone: requires extensive zoom in
 - Country names in country's language and alphabet
 - But city names in Latin alphabet with American English spelling

Small Scale Map: Continent Level (Africa): Observations (2)

1. MapQuest: Good cartography including topography and readable labels
2. Bing Maps
3. Nokia and Bing Maps:
 - Similar due to adoption of unified map design for user's experience
 - Hierarchical consistency: Only Bing but non-uniform font point size, curved labels, some use of abbreviations
 - Bing App misses border of South Sudan but zoom finds it
4. WP:
 - Misses many countries
 - Essentially same as Nokia
5. ESRI:
 - Hierarchical consistency here (not in US)
 - Nice incorporation of topography
 - No labels without extensive zoom in

Medium Scale Map: Europe: iOS6(Old and New), iOS7, iOS5, WP



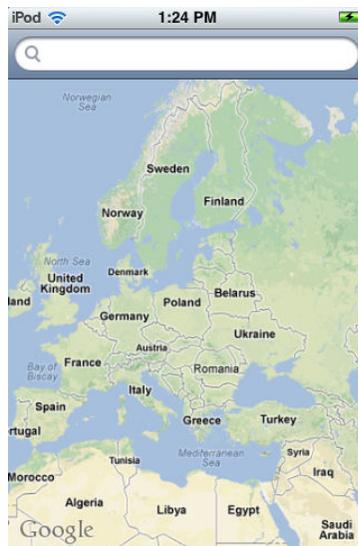
iOS6 Old



iOS6 New



iOS7



iOS5



WP

Medium Scale Map: Europe: Observations (1)

1. Android, iOS5, and iOS Google Maps are very similar
 - Only compare iOS6(old/new)/iOS7 Apple Maps and iOS5 Google Maps
2. iOS6(old/new)/iOS7 Apple Maps
 - Poor job of label placement
 - Hierarchically inconsistent (e.g., Rome without Italy in old/new iOS6 and Prague without Czech Republic in iOS7)
 - Labeled countries are not necessarily the most populated (e.g., missing France in old iOS6, Italy in both old and new iOS6, Germany and UK in new iOS6, Syria in new iOS6 and iOS7 but yes in iOS5)
 - Appears to give preference to countries near center of viewing window
 - Nonstandard country names (e.g., Alger instead of Algeria in old iOS6)
 - Poor choice of font (e.g., all caps which takes up much space)
 - Missing names of prominent water bodies unless zoom in much further (e.g., Mediterranean and North Seas while present in iOS5 Google Maps)

Medium Scale Map: Europe: Observations (2)

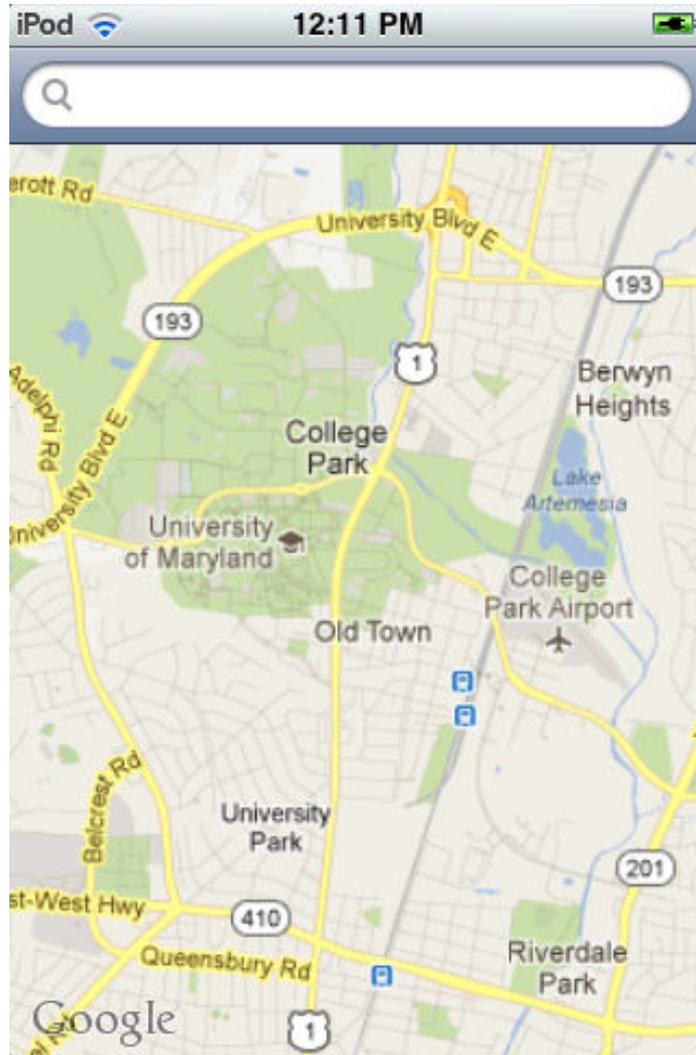
1. iOS5 Google Maps

- Better at deciding that map should be at country level
- Well-distributed names
- Hierarchical consistency

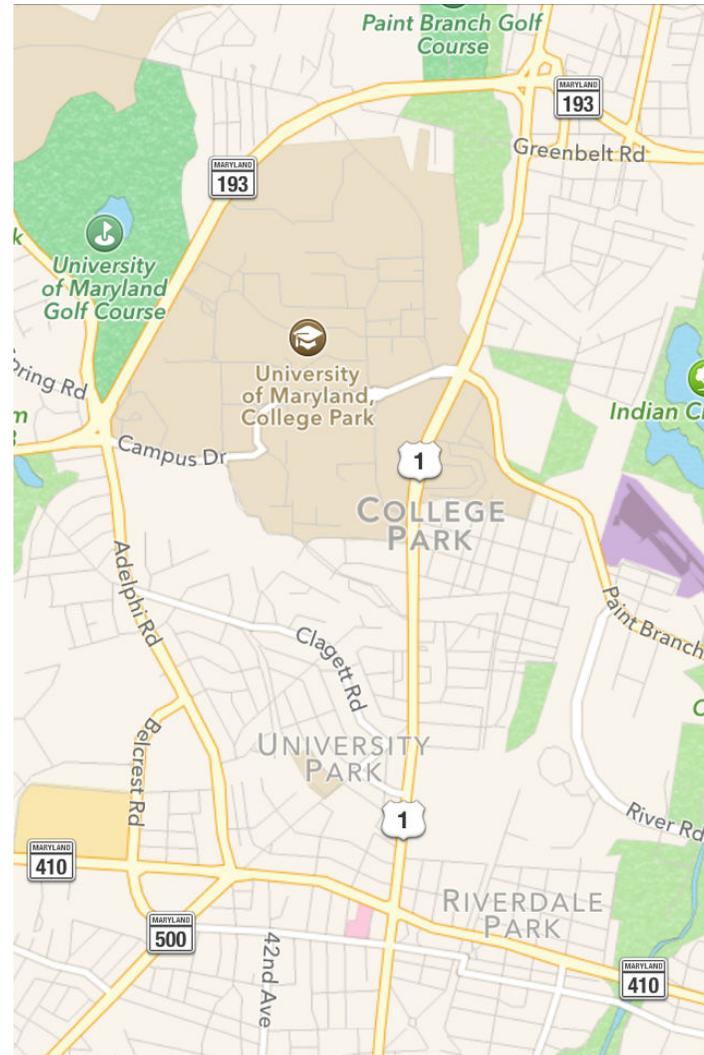
2. WP

- Different font point sizes for entities of the same type
 - Countries: Luxembourg vs France
 - Cities: Stuttgart vs Munich
 - Croatia very small in comparison to other countries (not shown)
- Non-uniform distribution of cities in countries
 - Only Paris, Lyon, Marseille, and Toulouse in France while many cities in Germany
- No hierarchical consistency
 - Belgrade but not Serbia (not shown)
- No zoom consistency
 - Croatia fades in and out as zoom in (not shown)

Local Map Level: iOS5, iOS7

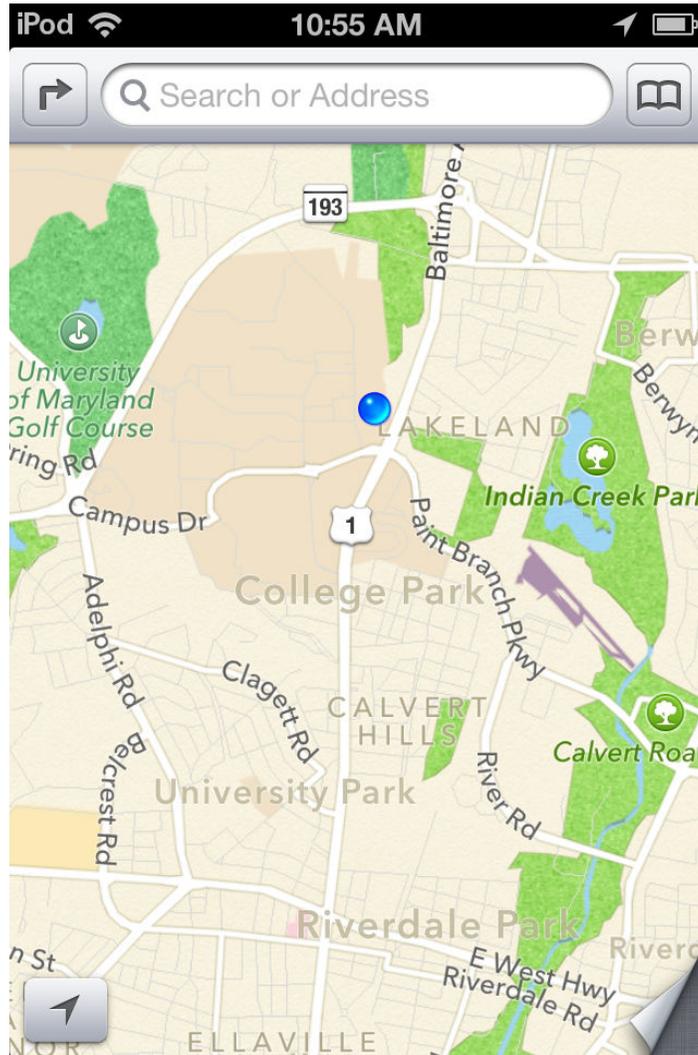


iOS5

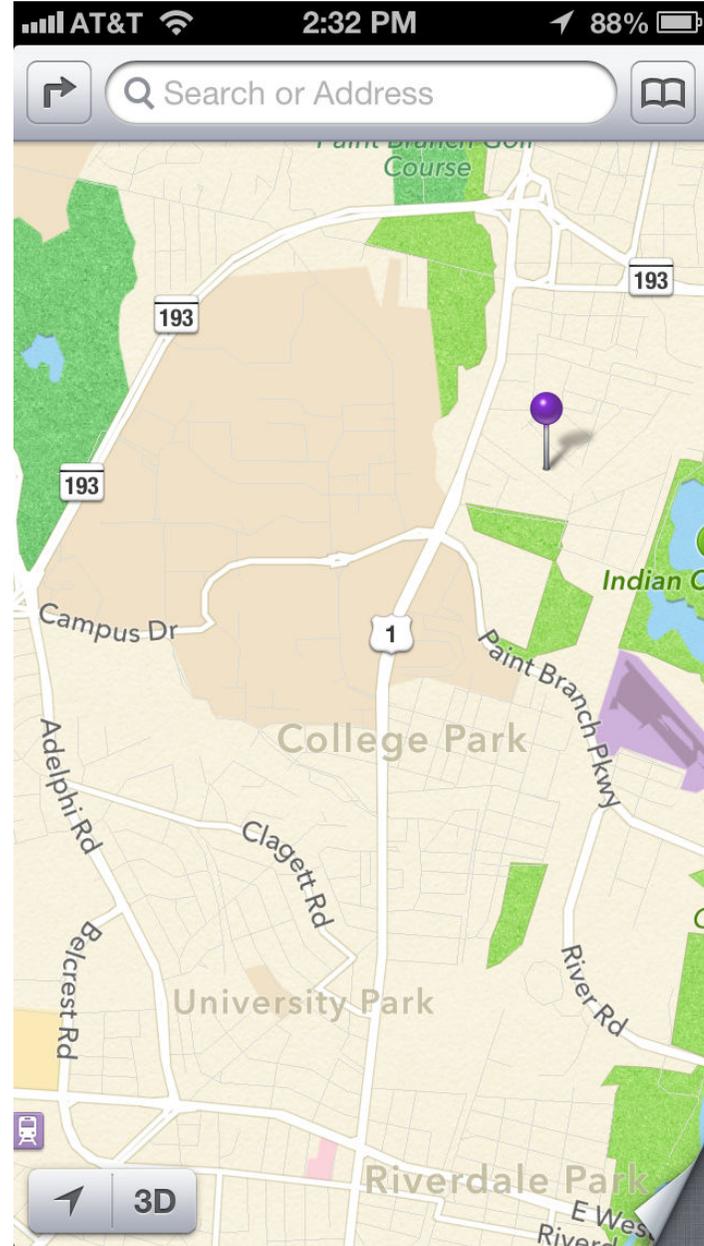


iOS7

Local Map Level: iOS6 (Old/New)

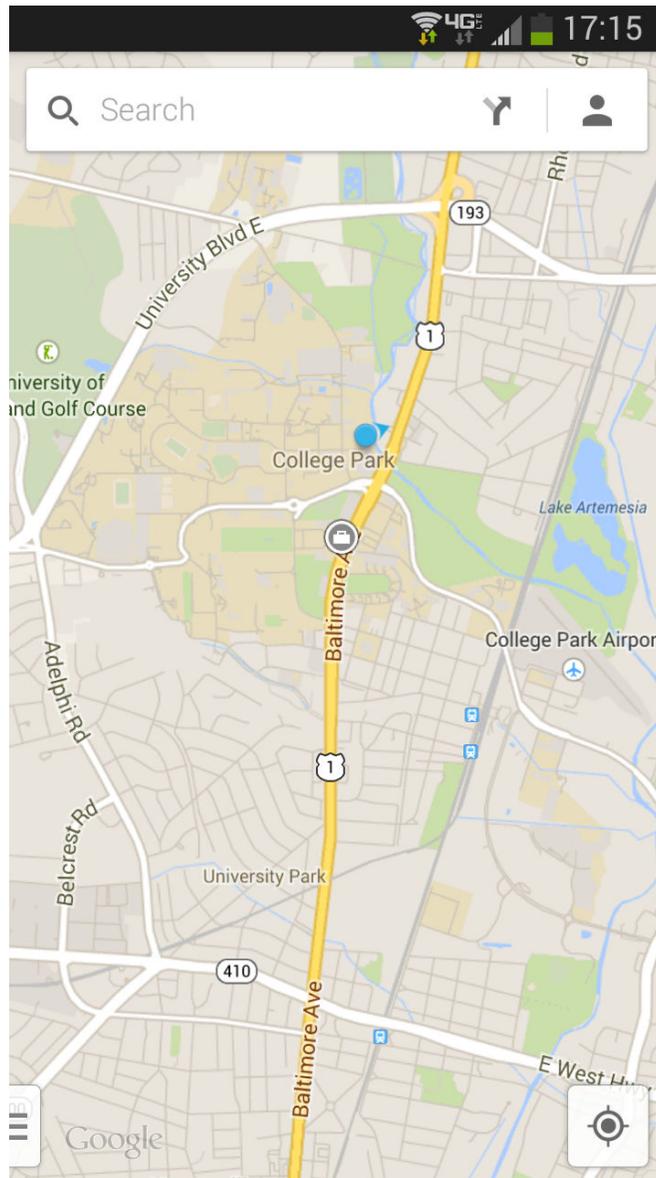


iOS6 old

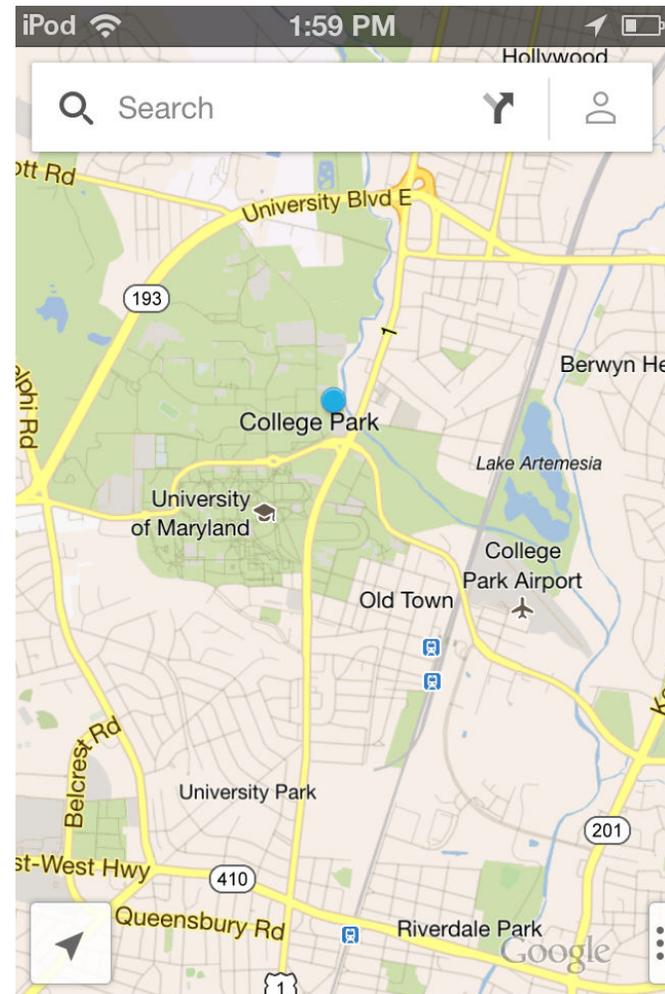


iOS6 new

Local Map Level: Android, iOS Google

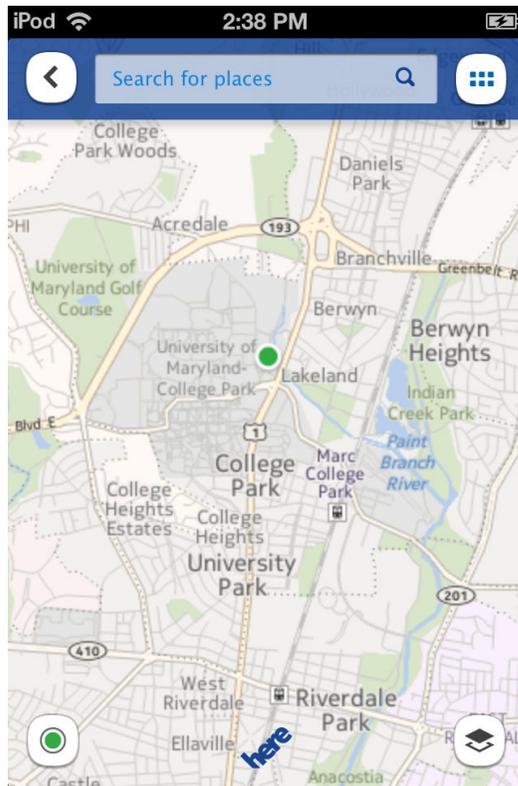


Android

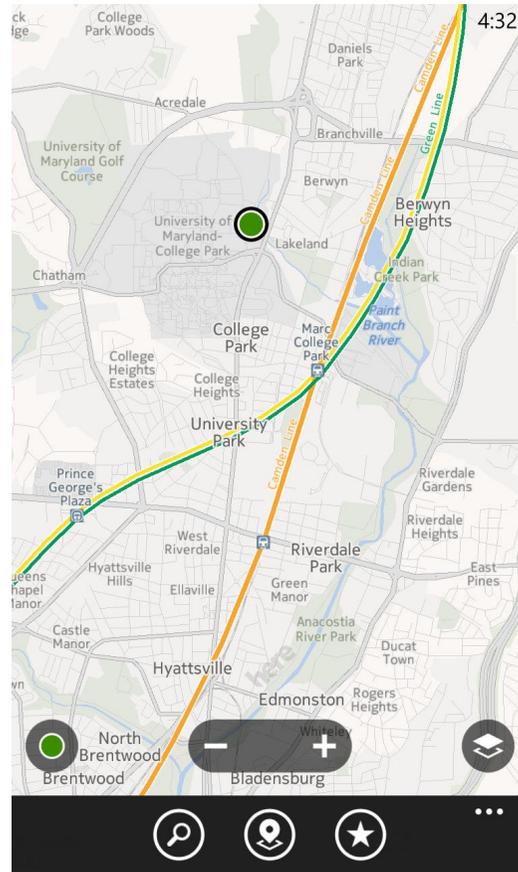


iOS Google

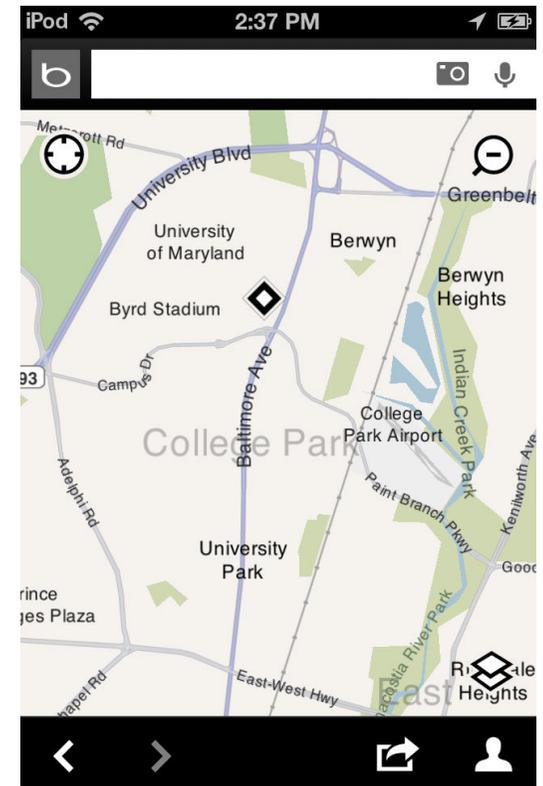
Local Map Level: Nokia, WP, Bing



Nokia

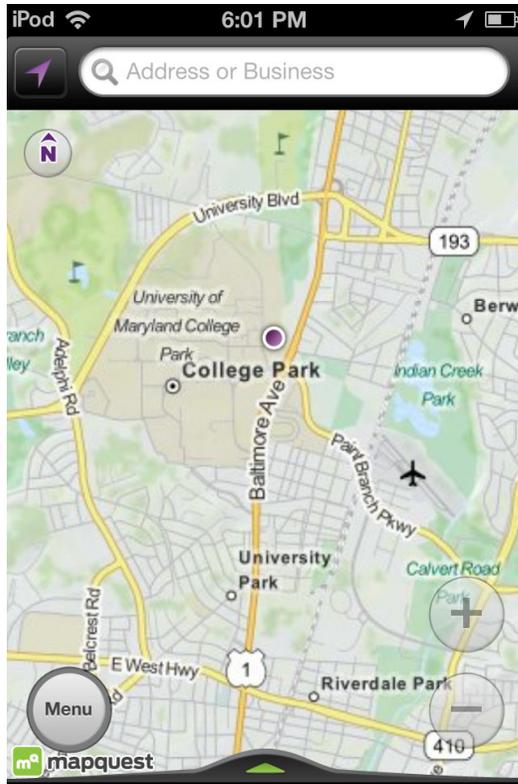


WP

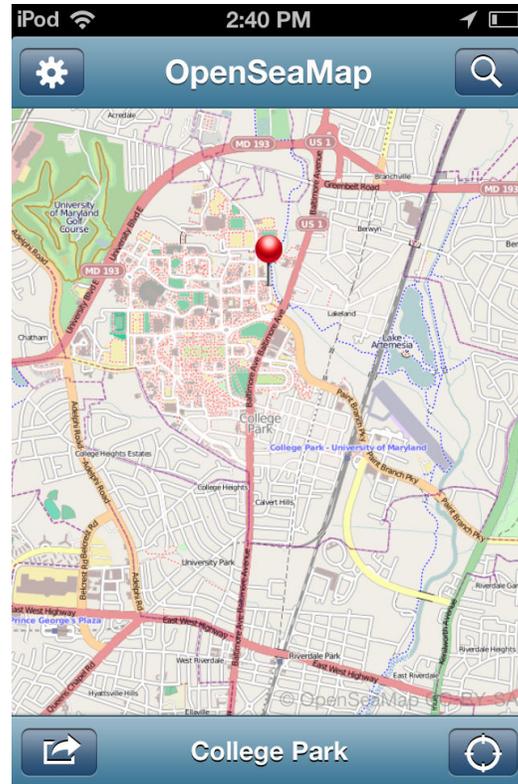


Bing

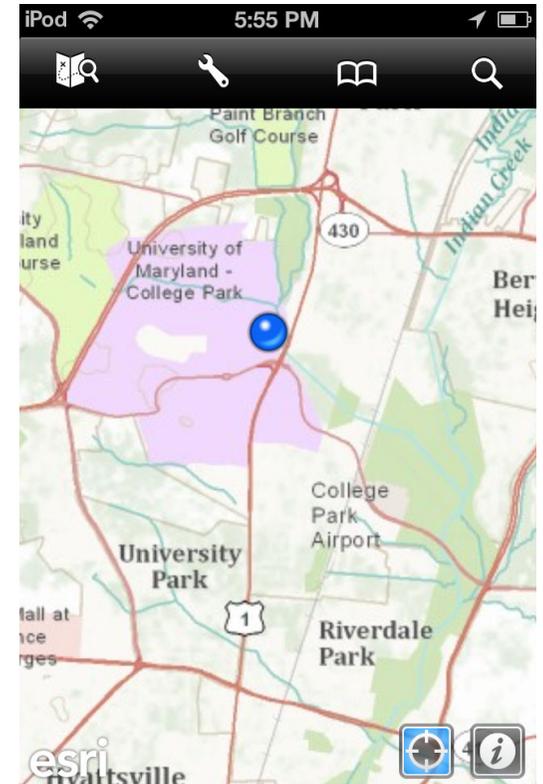
Local Map Level: MapQuest, OSM, ESRI



MapQuest



OSM



ESRI

Local Map Level: Observations (1)

1. Finding points of interest or orienting selves with respect to surroundings
2. iOS6 Apple Maps and OSM miss the University of Maryland
 - Not accidental for iOS6 Apple Maps as need much zooming for it to appear
 - Rectified in iOS7 Apple Maps
 - Too much detail in OSM
3. Google Maps:
 - Displays about the same number of street names as iOS6/7 Apple Maps
 - Fewer neighborhood names than old iOS6 Apple Maps
 - New iOS6 and iOS7 Apple Maps have less than old iOS6
 - Uses yellow to distinguish major streets for which names are provided (also iOS7 Apple Maps) in contrast to minor streets for which no names are provided and shown as lines
 - Android further distinguishes between labeled major streets by using white for lesser important ones
 - Uses same font, font point size, and color for names of some objects (i.e., roads, parks, towns, etc.)

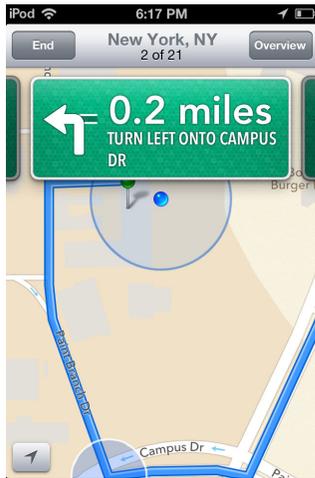
Local Map Level: Observations (2)

1. iOS6 Apple Maps
 - Uses watermark style for towns and neighborhoods, normal font and black color for roads, and italics for non-road features like parks
 - Town names
 - Old and new iOS6 display as proper nouns with upper and lower case letters
 - iOS7 Apple Maps uses large and small caps for town names
 - Uses one line for most multi word town names
 - But iOS7 Apple Maps uses mostly multiple lines
2. Bing Maps has similar information as Google Maps
 - Although Bing makes use of variable font point sizes and a watermark style for names of towns and neighborhoods
3. WP is similar to Nokia Maps
 - Not surprising as both use HERE Maps

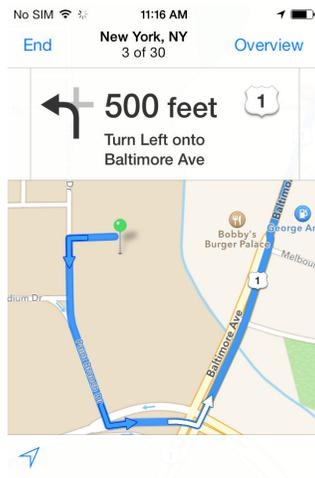
Local Map Level: Observations (3)

1. MapQuest presentation is similar to Google Maps
 - But fewer neighborhood names
2. OSM displays the richest variety of symbology differentiating between many feature types as well as labeling major roads although
 - However, no identification of any points of interest
3. Nokia Maps presentation not as vivid as Apple Maps in the sense of less use of color and a heavy use of watermark style for labels
4. Like Apple Maps, Nokia Maps and OSM identify far more names of towns and neighborhoods
 - Edge to Nokia over Apple
 - Overall edge to OSM although not readable on smartphone form factor without significant zoom
5. ESRI is relatively data poor although providing a stronger differentiation between major and minor roads
 - But out of date data such as Route 430

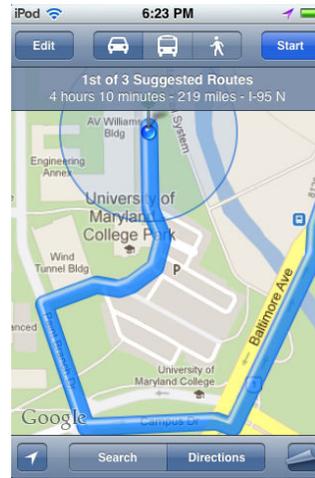
Large Scale: Navigation Level



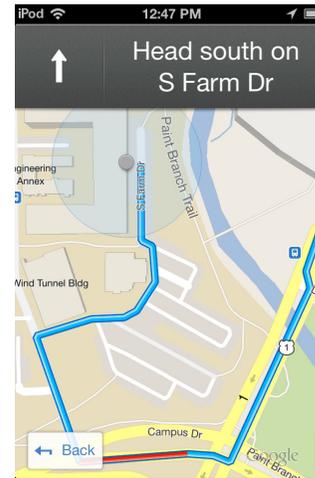
iOS6



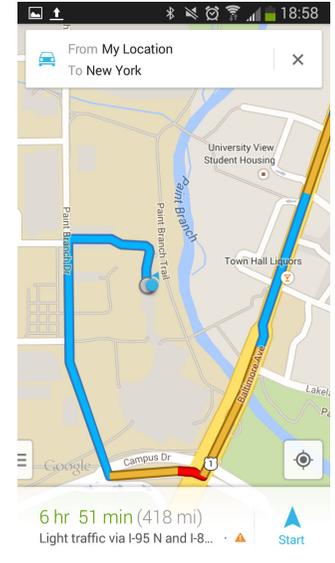
iOS7



iOS5



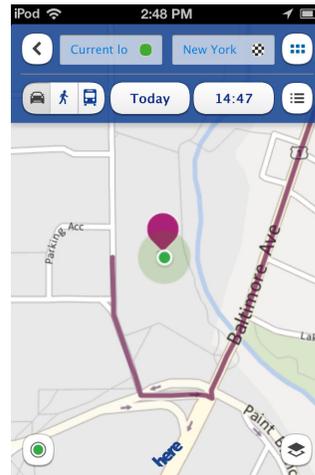
iOS Google



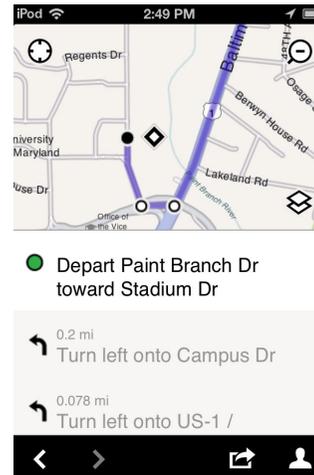
Android



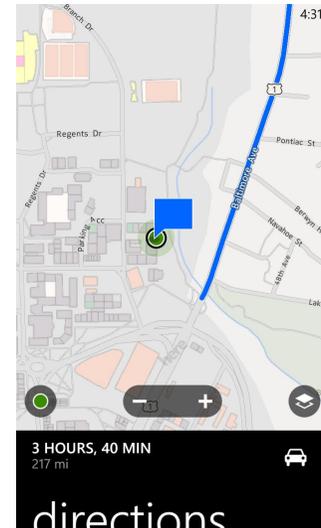
MapQuest



Nokia



Bing



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Large Scale: Navigation Level: Observations

1. Navigation/Directions from AV Williams Bldg. at UMD to NY city
 - No such capability with ESRI and OSM
2. iOS6, iOS7, iOS Google Maps, MapQuest display navigation
3. iOS5, Android, Nokia, Bing, and WP display directions
4. iOS6 Apple Maps is clearest with bold/ large display of next navigation step
 - iOS7 Apple Maps not as clear but gives arrows to guide path
 - Very useful when device moves such as falling to the floor
 - iOS Google Maps and MapQuest are also quite clear
5. Need to scroll to get directions in WP while not in Bing Maps
6. Building names:
 - Yes for Google Maps
 - No for Apple (iOS6/7), Bing, Nokia, WP, and MapQuest Maps
 - Although some outlines in Apple (iOS6/7) after much zooming in
7. Parking lots and driveways
 - No for Apple (iOS6/7) and MapQuest (only vis-a-vis MapQuest App)
 - Prominent ones such as those at airports and stadiums
 - Yes for Google Maps
 - Yes for Nokia and Bing Maps, WP, and web version of MapQuest

Smallest Scale Map: World Portrait: iOS6, iOS7, iOS Google, Android, Nokia, iOS5, OSM, ESRI, Bing, WP, MapQuest



iOS6 (Africa)



iOS6 (Asia)



iOS7



iOS Google



Android



Nokia



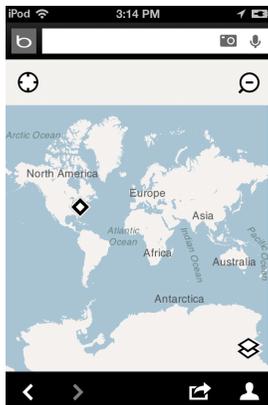
iOS5



OSM



ESRI



Bing



WP



MapQuest

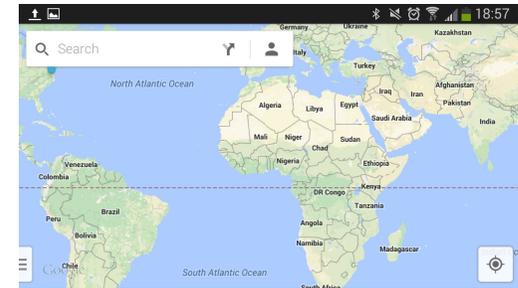
Smallest Scale Map: World Landscape: iOS6, iOS5, Android, iOS Google, MapQuest, Nokia, Bing, OSM, ESRI, but No WP



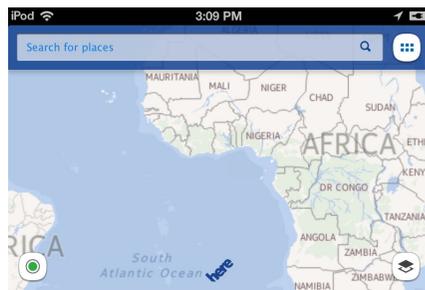
iOS6



iOS5



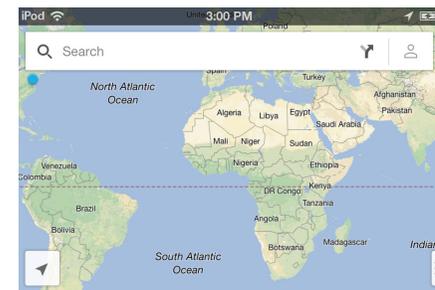
Android



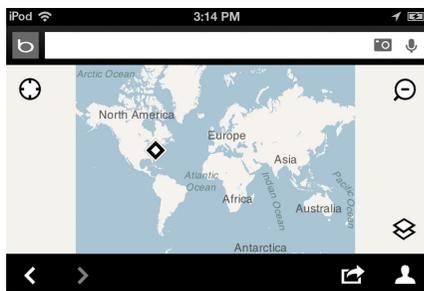
Nokia



MapQuest



iOS Google



Bing



OSM



ESRI

Smallest Scale Map: World Landscape and Portrait: Scope

1. iOS5 Google Maps, Bing Maps, ESRI, and OSM: almost entire world
2. WP: almost entire world but no landscape variant
3. Nokia Maps and and MapQuest: narrower world view
4. iOS6/7 Apple Maps
 - Somewhere in middle of two extremes of almost entire world with iOS5 Google Maps and small part of the world with Nokia Maps and MapQuest
 - iOS7 Apple Maps differs from iOS6 Apple Maps by having bold face instead of watermarks for continent names
5. iOS Google Maps and Android
 - Almost identical in geographic scope to iOS6/7 Apple Maps
 - Many place names and relatively well-distributed and readable especially in contrast to iOS6/7 Apple Maps where so few are labeled

Smallest Scale Map: World Landscape and Portrait: Contents

- iOS6/7 Apple Maps: cities, continents, and oceans (but never Southern)
 - Need to zoom in for South Atlantic
 - More cities in iOS7 Apple Maps landscape than iOS6 Apple Maps landscape
- iOS6 Apple Maps Portrait has panning and sibling inconsistency
 - No objects when center in Africa and cities when center in Asia
- iOS5 Google Maps: continents and 3 oceans
 - Need to zoom in for Southern and Arctic
- Android and iOS Google Maps: only countries and 4 oceans
 - Can't zoom so far out to see continents but need to zoom in for Arctic
- Bing Maps: continents and oceans
 - Need to zoom in for South America and Southern
- WP: unlike Bing Maps, all continents and all oceans
- ESRI: No labels
- Nokia Maps: countries, continents, and oceans (via panning)
- MapQuest: cities, countries (no hierarchical consistency), continents, oceans (but never Southern)

Smallest Scale Map: Mashup Utility Examples

- Need to see entire world when want to observe feature's global behavior with one view rather than having to pan map to see behavior's full extent
- Ex: NewsStand (note slider to increase number of feature entities)



iOS6 Icon



iOS5 Icon



iOS6 Disease



iOS5 Disease

Midscale Map: Country Landscape (US): iOS6, OSM, iOS5, Android



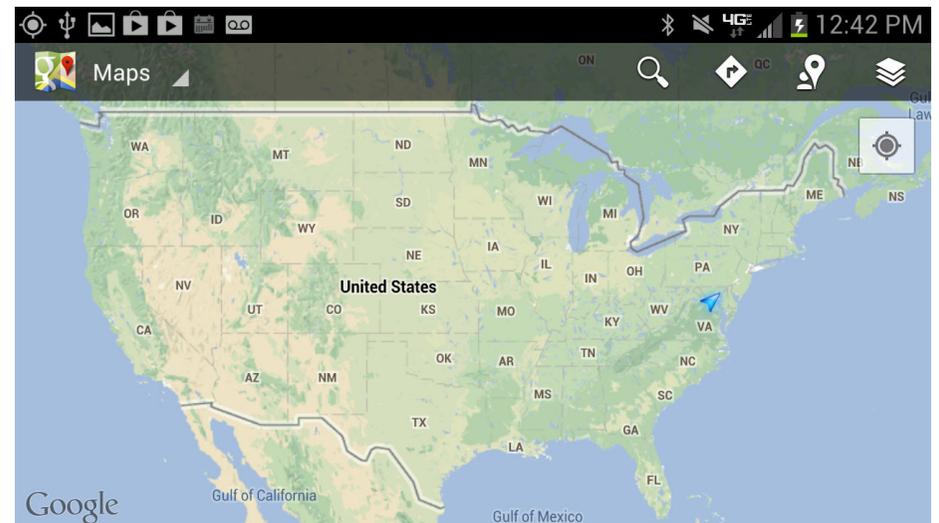
iOS6



OSM

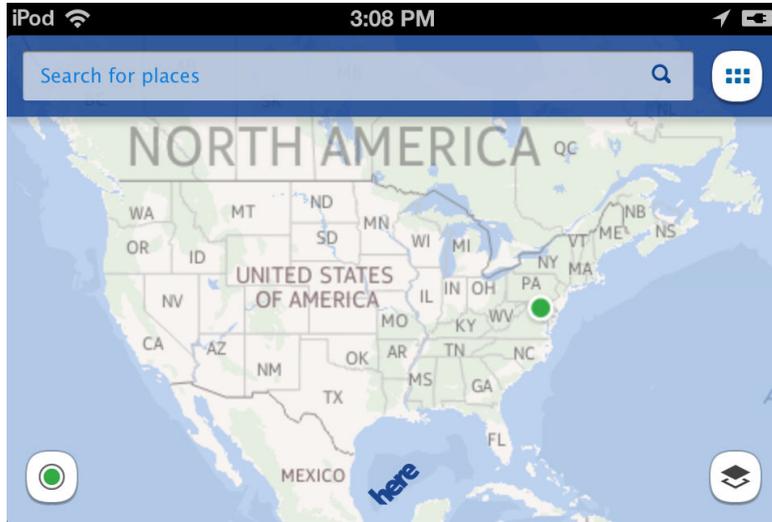


iOS5



Android and iOS Google (same)

Midscale Map: Country Landscape (US): Nokia, Bing, MapQuest, ESRI



Nokia



Bing



MapQuest



ESRI

Midscale Map: Country Landscape (US): Observations

- (1). ESRI and MapQuest display same relative amount of detail as they do at the world level (too little for ESRI and a reasonable amount for MapQuest)
2. Number and type of labeled places
 - iOS6/7 Apple, MapQuest, and ESRI: a few cities and country names
 - Hierarchically inconsistent as no state names
 - iOS7 almost same cities as iOS6 but no name of containing country, US
 - Google Maps (iOS5, iOS, and Android), Nokia Maps, Bing Maps, and OSM: label states?
 - iOS5: all with pointers where not enough room (sibling consistency)
 - OSM: all but reduce point size of font (sibling consistency)
 - Nokia, Bing, iOS, and Android are similar but sometimes omit even if have room as with Alabama in Android and iOS on Google Maps, and Washington on Bing Maps (sibling inconsistency)
3. No WP as no landscape mode
4. iOS Google maps and Android are the same

Midscale Map: Country Landscape (US): Observations (2)

1. Often use abbreviations so can fit more
 - Should be consistent which means coming from the same source
 - Google Maps and OSM use USPS (US Postal Service)
 - iOS6/7 Apple and Bing Maps use the AP (Associated Press)
 - Bing Maps only uses abbreviations when full name cannot fit
2. Zoom in and pan with caching can lead to mixing abbreviations and names in old versions of iOS Google Maps (Bing has it)

Topography

- Bing and OSM show none, at least at small scale
- iOS5, iOS, Android, MapQuest, and ESRI show it at small scale
- iOS6/7 Apple Maps and Nokia (WP is same) show some topography with less on Nokia (WP) and even less on iOS7
- Not meaningful at large scale like navigation and local maps
- Note contrast between iOS6 and three Google Maps variants iOS5, iOS, and Android for small scale (e.g., Africa) which are essentially the same



iOS6



iOS5



Android



iOS Google

Concluding Remarks

- iOS5, iOS, and Android Google Maps are similar save for US landscape, entire world (both portrait and landscape), and African countries
- Respect for small form factor of smartphone:
 - Google Maps (iOS5, iOS, and Android) appreciates it
 - Emphasizes readable labels for entities (e.g., places, roads, etc.)
 - Color contrast and nice spatial distribution
 - Readable font type, color, and size (but different point sizes as in Gabon and Algeria)
 - Avoids watermark style labels which are not easily read in daylight
 - iOS6/7 Apple Maps:
 - Label placement and spatial distribution are poor often due to use of large fixed-width font point sizes and sometimes all caps
 - Less of an issue on larger form factor devices such as iPad
 - ESRI: almost no labels
 - OSM: ignores by having microscopic size labels and a busy screen
 - MapQuest: too many features such as topography but informative
 - Watermark style can alleviate busy screen but should not overdo
 - Can't be too busy so can anchor spatially-referenced information such as icons for mashups (e.g., NewsStand, TwitterStand, PhotoStand)
 - WP incorporates one of Nokia or Bing which are converging