[0059] Image distribution systems that accommodate interactive display, printing and saving (i.e. downloading) can operate by (i) storing large digital images on server computers, (ii) accepting user requests for image data from client computers, each request being determined by a resolution independent rectangular portion and a pixel array size, and (iii) responding to such requests by transmitting appropriate image data from a server to a client. The Flashpix image format and the Internet Imaging Protocol, as described hereinbelow, were designed to make Internet image distribution systems as efficient as possible, by administering a "just enough data" policy and transmitting only the minimal amount of image data necessary to satisfy a client request

[0060] Referring back to the abovementioned example of the 6"×8" photograph, the 3,600×4,800 original image occupies a total of 3×3,600×4,800=51.84 MB uncompressed, at a pixel depth of 3 bytes per pixel. High fidelity compression such as JPEG typically reduces this by an order of magnitude to roughly 5 MB. In the first scenario above, where the user requests the entire image to be displayed at 432×576 pixel resolution, the image to be displayed occupies only 3×432×576=746,496 bytes uncompressed, which corresponds to approximately 75 KB compressed. Rather than transmit the entire 5 MB of image data from the server to the client, an efficient image distribution system transmits only the 75 KB of data, or slightly more, necessary to render the desired display image.

[0061] Flashpix Image Format

[0062] Multi-resolution tiled (MRT) image formats are particularly well-suited for storing resolution independent images in such a way that specified rectangular portions of such an image can be efficiently generated at specified pixel resolutions. An MRT format stores the original image together with the successively reduced versions of the image. Moreover the image data for the original image and for each reduced version thereof is partitioned into blocks called tiles. As such, an MRT format is redundant in that the reduced versions of the image can be generated form the original image data but are nevertheless stored in the file. However, the advantage of the MRT format is that lower resolution image data is readily available, and the tile structure makes it simple to access rectangular portions of the image.

[0063] FLASHPIX, a trademark of the Digital Imaging Group (DIG), is an example of an MRT image format A Flashpix image is generated by starting with an original image and recursively subsampling it at half of the previous resolution. The recursion continues until the final subsampled image is reduced to a size of 64 pixels or less in each dimension Each resolution level is partitioned into image tiles that are 64×64 pixels in size, and the individual tiles can be stored as uncompressed or JPEG compressed image data. A reference for Flashpix is the document "Flashpix Format Specification,"© 1996, 1997, Eastman Kodak Company, the contents of which are hereby incorporated by reference.

[0064] Referring back to the abovementioned example, the 3,600×4,800 pixel image would be stored as a Flashpix image with eight resolution layers as follows:

Layer #7:	3,600 × 4,800
Layer #6:	1,800 × 2,400
Layer #5:	900 × 1,200
Layer #4:	450 × 600
Layer #3:	225 × 300
Layer #2:	113 × 150
Layer #1:	57 × 75
Layer #0:	29 × 38

[0065] Each of these layers would be partitioned into a set of tiles, each tire being 64×64 pixels in size.

[0066] Reference is now made to **FIG. 2**, which is an illustration of a portion of an image and its relationship to tiles in one of the resolution layers, used in connection with a preferred embodiment of the present invention. **FIG. 2** illustrates how tiles are identified to satisfy a user request to view the top left quadrant of the above Flashpix image in a viewing window of 240×320 pixels. The requested image portion is (0, 0, 0.5, 0.5), using the notation for resolution independent rectangles described hereinabove, and the requested pixel dimensions are 240×320. This corresponds to a sampling frequency of 7.5 in each dimension.

[0067] The closest resolution layer in the Flashpix image that does not exceed this sampling frequency is Layer #5, designated by reference numeral **230**, which has a sampling frequency of 4 in each dimension. The requested image portion can be generated by reducing the top left quadrant of the 900×1,200 resolution layer by a factor of 8/15. As illustrated, Layer #5 has 15 rows of tiles, each row having 19 tiles, the tiles being designated by reference numerals **240**. Observe that some of the tiles extend beyond the right and bottom borders of the image in Layer #5. To obtain the top left quadrant image portion (0, 0, 0.5, 0.5) designated by reference numeral **250**, it is necessary to extract data from the first 10 tiles in each of the top 8 rows of tiles, as these are the tiles that overlap with the image portion (0, 0, 0.5, 0.5). If the tiles are numbered serially from 0 to 284, as illustrated in **FIG. 1**, then the necessary tiles are 0-9, 19-28, 38-47, 57-66, 76-85, 95-104, 114-123 and 133-142.

[0068] These tiles can be retrieved from the Flashpix image and combined into a single image of dimensions 512×640 pixels. The combined image can then be cropped to a size of 450×600 pixels by cutting off the excess tile spillage at the right and bottom borders. The cropped image can be reduced by a factor of 8/15 to the desired target size of 240×320 pixels. This is more efficient than beginning with the full 3,600×4,800 pixel original image and re-sizing by a factor of 2/15.

[0069] In the above example, Layer #5 was chosen rather than Layer #4, since the top left quadrant of Layer #4 would have produced an image of 225×300 pixels, which would then have had to be enlarged by a factor of 16/15. Typically it is desirable to avoid enlargements, since they stretch the image beyond its original dimensions and introduce additional color data, such as interpolated color values, to the original image data.

[0070] Flashpix image data can be specified in standard RGB or PhotoYCC color spaces, or in another calibrated color space designated by an appropriate International Color Consortium (ICC) profile. The image data may also include