US 20150302130A1

(19) **United States**

(12) **Patent Application Publication**

Hirschman et al.

(10) **Pub. No.: US 2015/0302130 A1**

(43) **Pub. Date: Oct. 22, 2015**

(54) **METHOD AND SYSTEM FOR VERIFYING PRINTED CIRCUIT BOARD DESIGNS, AND CREATING OR VERIFYING RELATED ELECTRONIC COMPONENT PLACEMENT DATA FOR PRINTED CIRCUIT BOARD FABRICATION AND ASSEMBLY**

(71) Applicant: **PCB:NG, Inc.**, Brooklyn, NY (US)

(72) Inventors: **Jonathan Hirschman**, Brooklyn, NY (US); **Petro Bakhirev**, Brooklyn, NY (US); **James Graham**, Brooklyn, NY (US)

(21) Appl. No.: **14/587,870**

(22) Filed: **Dec. 31, 2014**

Related U.S. Application Data

(60) Provisional application No. 61/922,106, filed on Dec. 31, 2013.

Publication Classification

(51) **Int. Cl.**

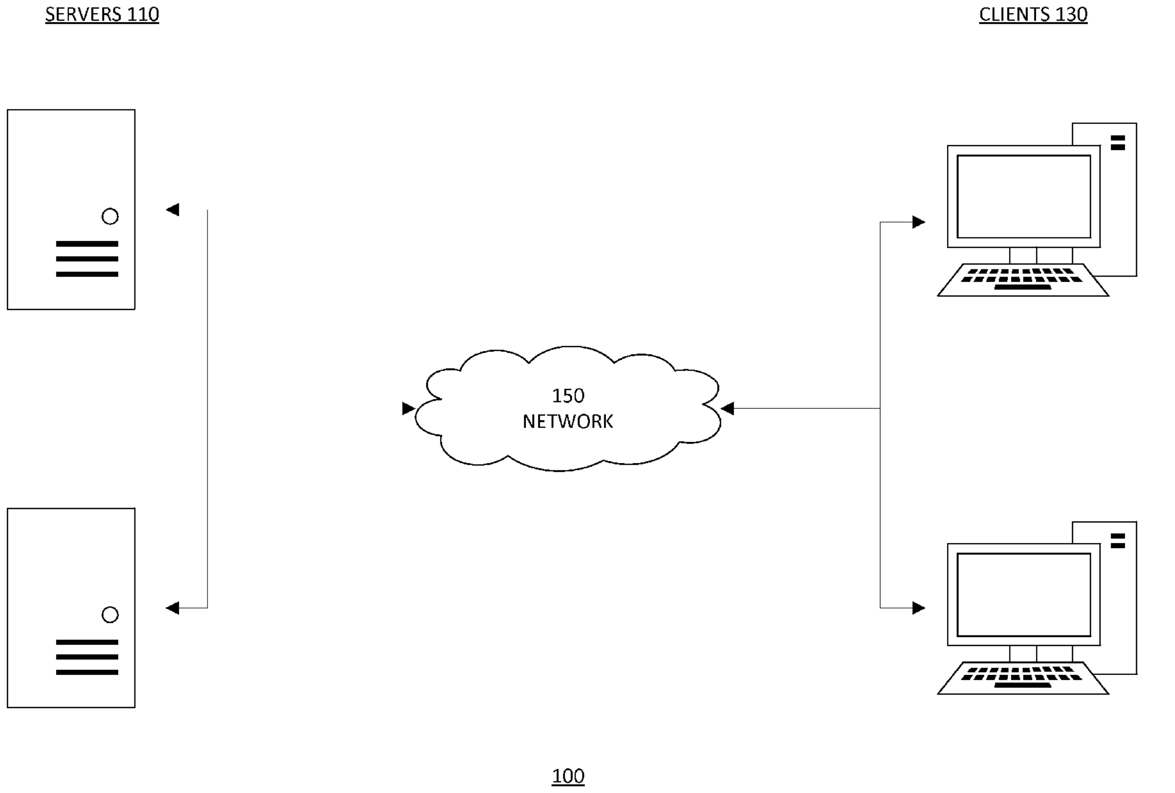
G06F 17/50	(2006.01)
G06F 3/0482	(2006.01)
H05K 3/00	(2006.01)
G06F 3/0484	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 17/5072*** (2013.01); ***G06F 3/04847*** (2013.01); ***G06F 3/0482*** (2013.01); ***G06F 3/04842*** (2013.01); ***G06F 17/5081*** (2013.01); ***H05K 3/0005*** (2013.01)

(57) **ABSTRACT**

A system for printed circuit board assembly includes a user interface provided on a display device for visual verification of printed circuit board design data, a user interface provided on the display device for inputting bill of material information, and a user interface provided on the display device for verification, alteration and creation of component placement data.



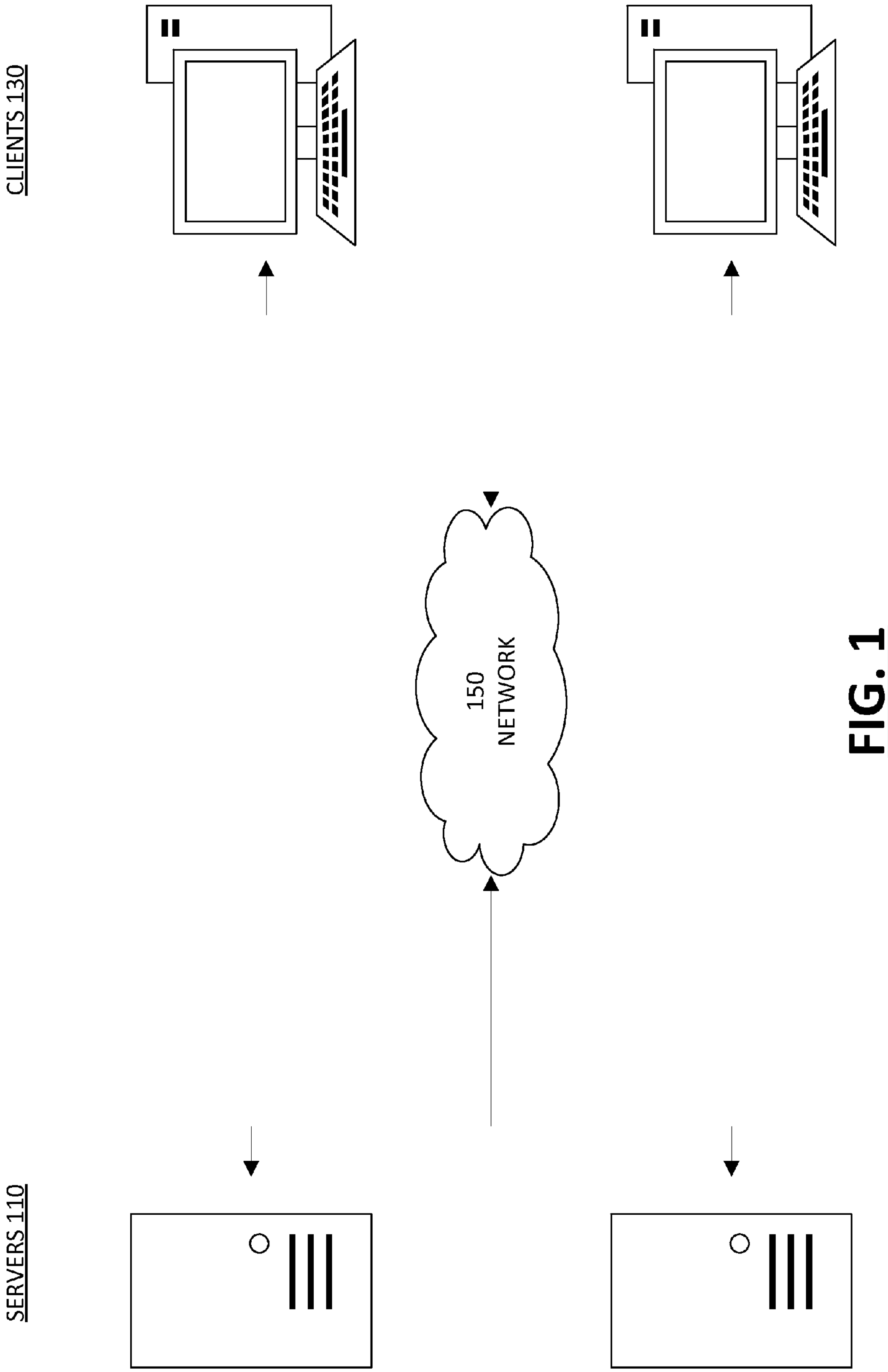


FIG. 1

100

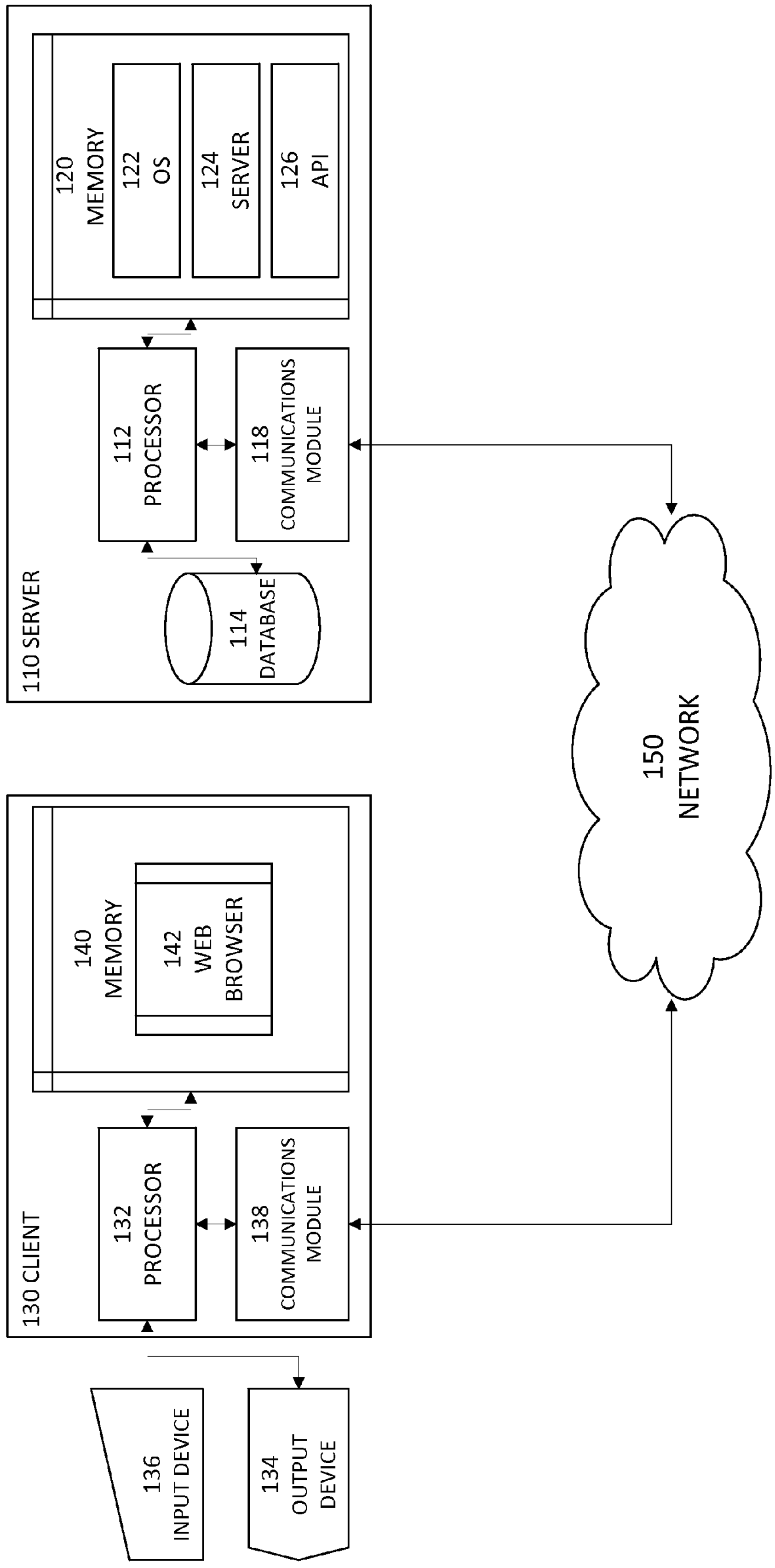

110 SERVER
120 MEMORY
122 OS
124 SERVER
126 API
112 PROCESSOR
118 COMMUNICATIONS MODULE
114 DATABASE
150 NETWORK
130 CLIENT
140 MEMORY
142 WEB BROWSER
132 PROCESSOR
138 COMMUNICATIONS MODULE
136 INPUT DEVICE
134 OUTPUT DEVICE

FIG. 2

200

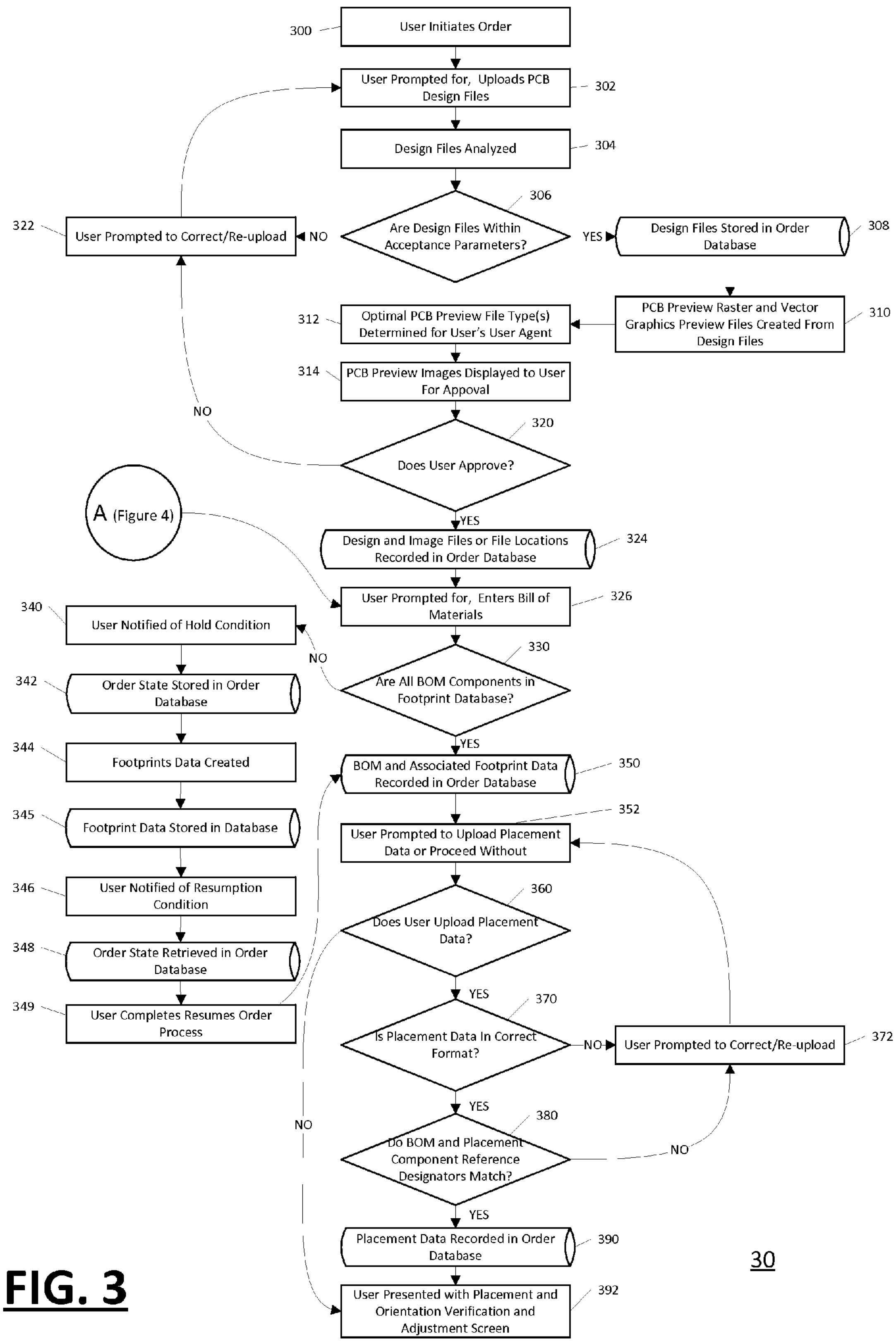

300
User Initiates Order
User Prompted for, Uploads PCB Design Files
302
Design Files Analyzed
304
306
Are Design Files Within Acceptance Parameters?
YES
Design Files Stored in Order Database
308
NO
User Prompted to Correct/Re-upload
322
PCB Preview Raster and Vector Graphics Preview Files Created From Design Files
310
312
Optimal PCB Preview File Type(s) Determined for User's User Agent
314
PCB Preview Images Displayed to User For Appoval
NO
320
Does User Approve?
A (Figure 4)
YES
Design and Image Files or File Locations Recorded in Order Database
324
User Prompted for, Enters Bill of Materials
326
340
User Notified of Hold Condition
NO
330
Are All BOM Components in Footprint Database?
342
Order State Stored in Order Database
344
Footprints Data Created
YES
BOM and Associated Footprint Data Recorded in Order Database
350
345
Footprint Data Stored in Database
352
User Prompted to Upload Placement Data or Proceed Without
346
User Notified of Resumption Condition
360
Does User Upload Placement Data?
348
Order State Retrieved in Order Database
349
User Completes Resumes Order Process
YES
370
Is Placement Data In Correct Format?
NO
User Prompted to Correct/Re-upload
372
NO
YES
380
Do BOM and Placement Component Reference Designators Match?
NO
YES
Placement Data Recorded in Order Database
390
30
User Presented with Placement and Orientation Verification and Adjustment Screen
392

FIG. 3

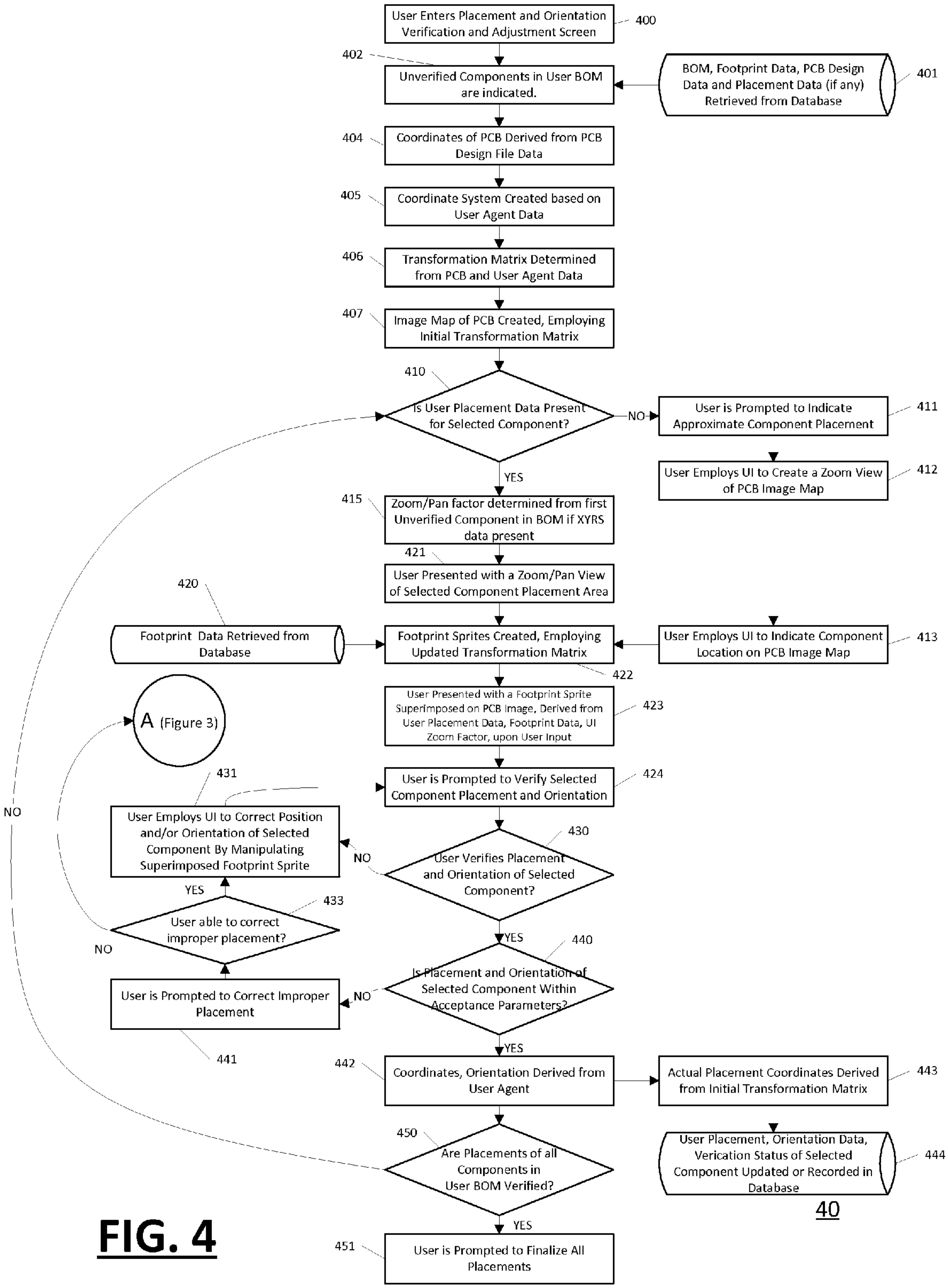
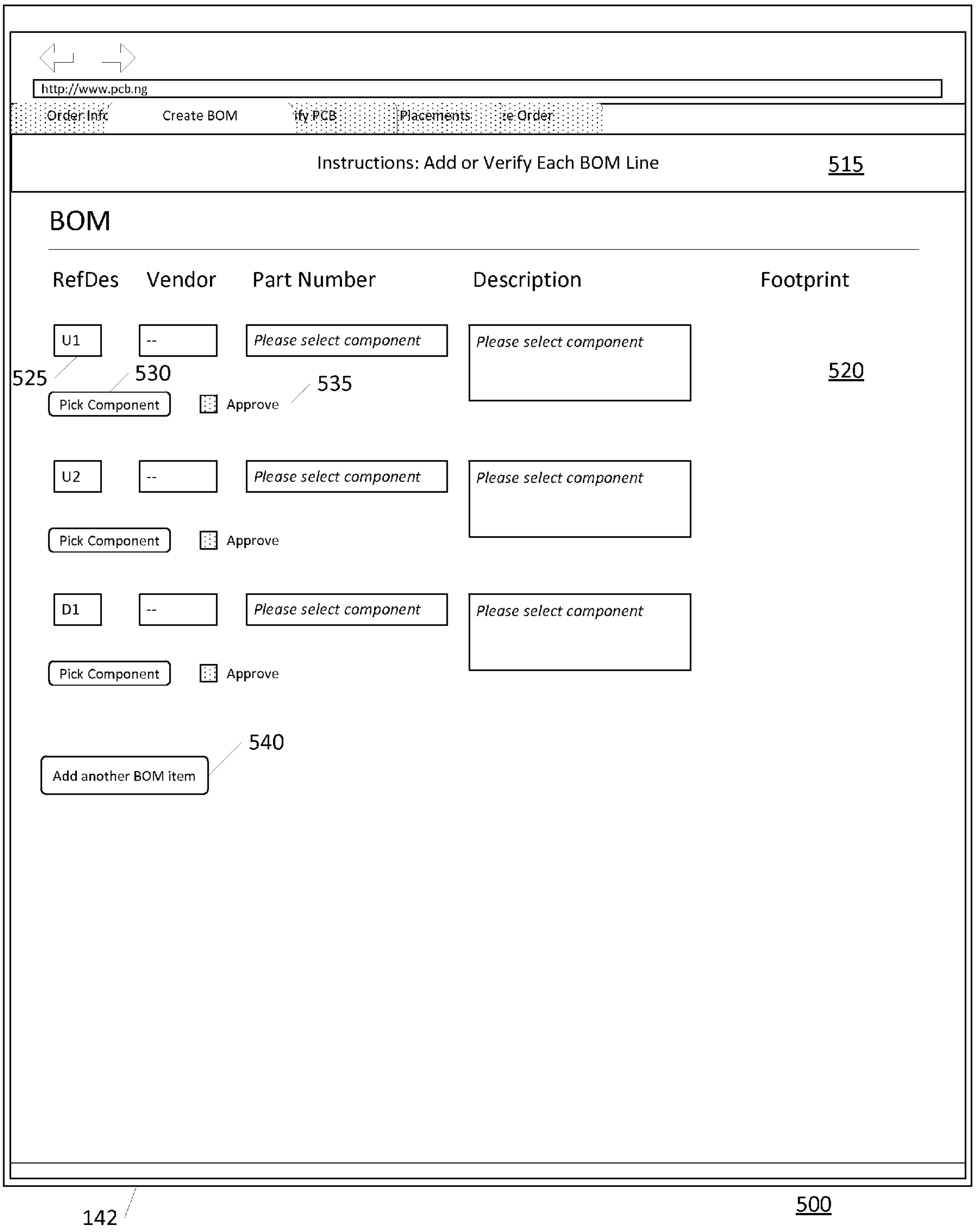

User Enters Placement and Orientation Verification and Adjustment Screen
400
402
Unverified Components in User BOM are indicated.
BOM, Footprint Data, PCB Design Data and Placement Data (if any) Retrieved from Database
401
404
Coordinates of PCB Derived from PCB Design File Data
405
Coordinate System Created based on User Agent Data
406
Transformation Matrix Determined from PCB and User Agent Data
407
Image Map of PCB Created, Employing Initial Transformation Matrix
410
Is User Placement Data Present for Selected Component?
NO
User is Prompted to Indicate Approximate Component Placement
411
User Employs UI to Create a Zoom View of PCB Image Map
412
YES
415
Zoom/Pan factor determined from first Unverified Component in BOM if XYRS data present
421
User Presented with a Zoom/Pan View of Selected Component Placement Area
420
Footprint Data Retrieved from Database
Footprint Sprites Created, Employing Updated Transformation Matrix
User Employs UI to Indicate Component Location on PCB Image Map
413
422
A (Figure 3)
User Presented with a Footprint Sprite Superimposed on PCB Image, Derived from User Placement Data, Footprint Data, UI Zoom Factor, upon User Input
423
NO
431
User is Prompted to Verify Selected Component Placement and Orientation
424
User Employs UI to Correct Position and/or Orientation of Selected Component By Manipulating Superimposed Footprint Sprite
430
NO
User Verifies Placement and Orientation of Selected Component?
YES
433
User able to correct improper placement?
NO
YES
440
Is Placement and Orientation of Selected Component Within Acceptance Parameters?
User is Prompted to Correct Improper Placement
NO
YES
441
442
Coordinates, Orientation Derived from User Agent
Actual Placement Coordinates Derived from Initial Transformation Matrix
443
450
Are Placements of all Components in User BOM Verified?
User Placement, Orientation Data, Verication Status of Selected Component Updated or Recorded in Database
444
40
YES
451
User is Prompted to Finalize All Placements

FIG. 4



http://www.pcb.ng

Order Infc | Create BOM | ify PCB | Placements | :e Order

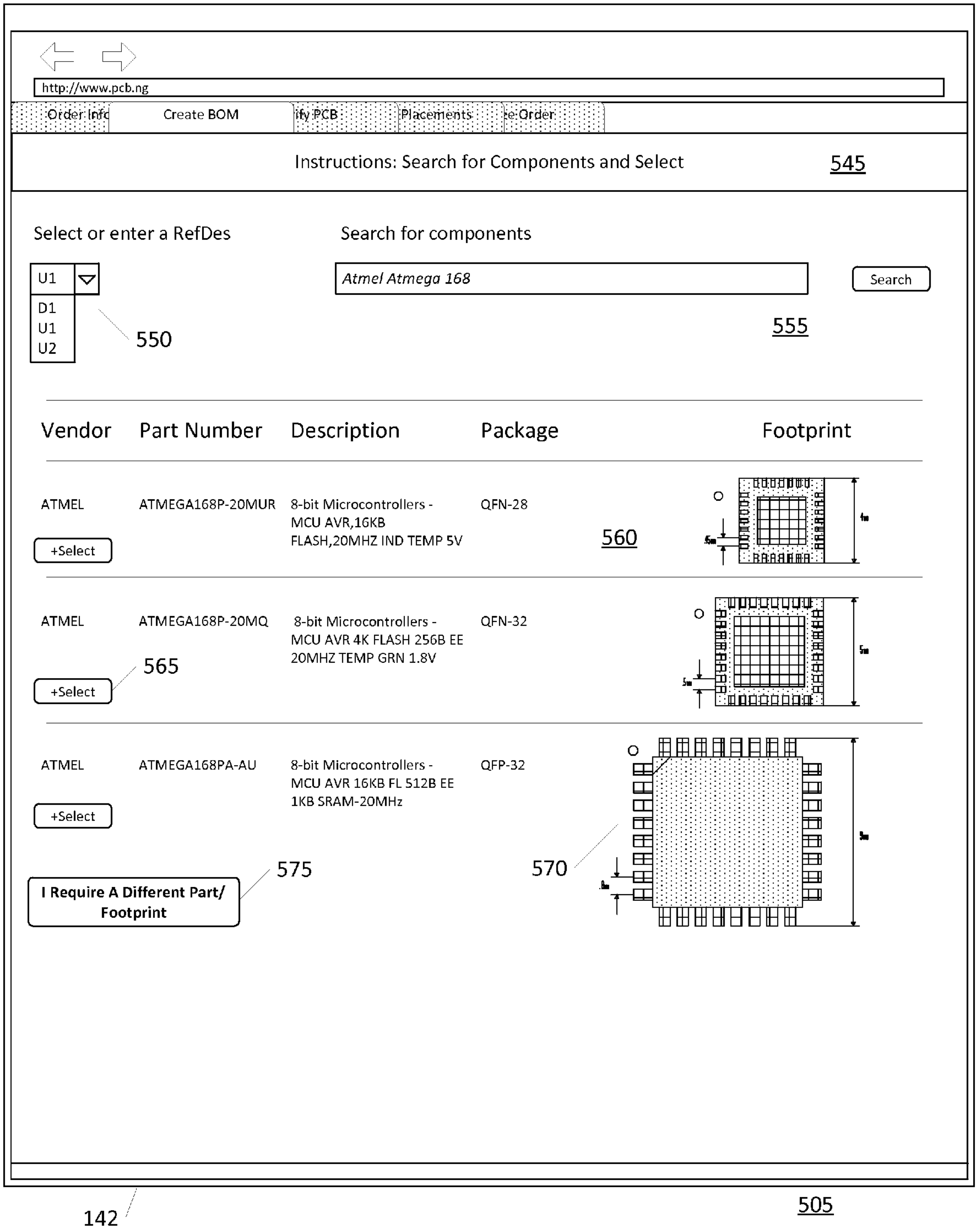
Instructions: Add or Verify Each BOM Line

BOM

RefDes	Vendor	Part Number	Description	Footprint
U1	--	*Please select component*	*Please select component*	
Pick Component	□ Approve			
U2	--	*Please select component*	*Please select component*	
Pick Component	□ Approve			
D1	--	*Please select component*	*Please select component*	
Pick Component	□ Approve			

Add another BOM item

FIG. 5A



Instructions: Search for Components and Select

Select or enter a RefDes

U1

D1
U1
U2

Search for components

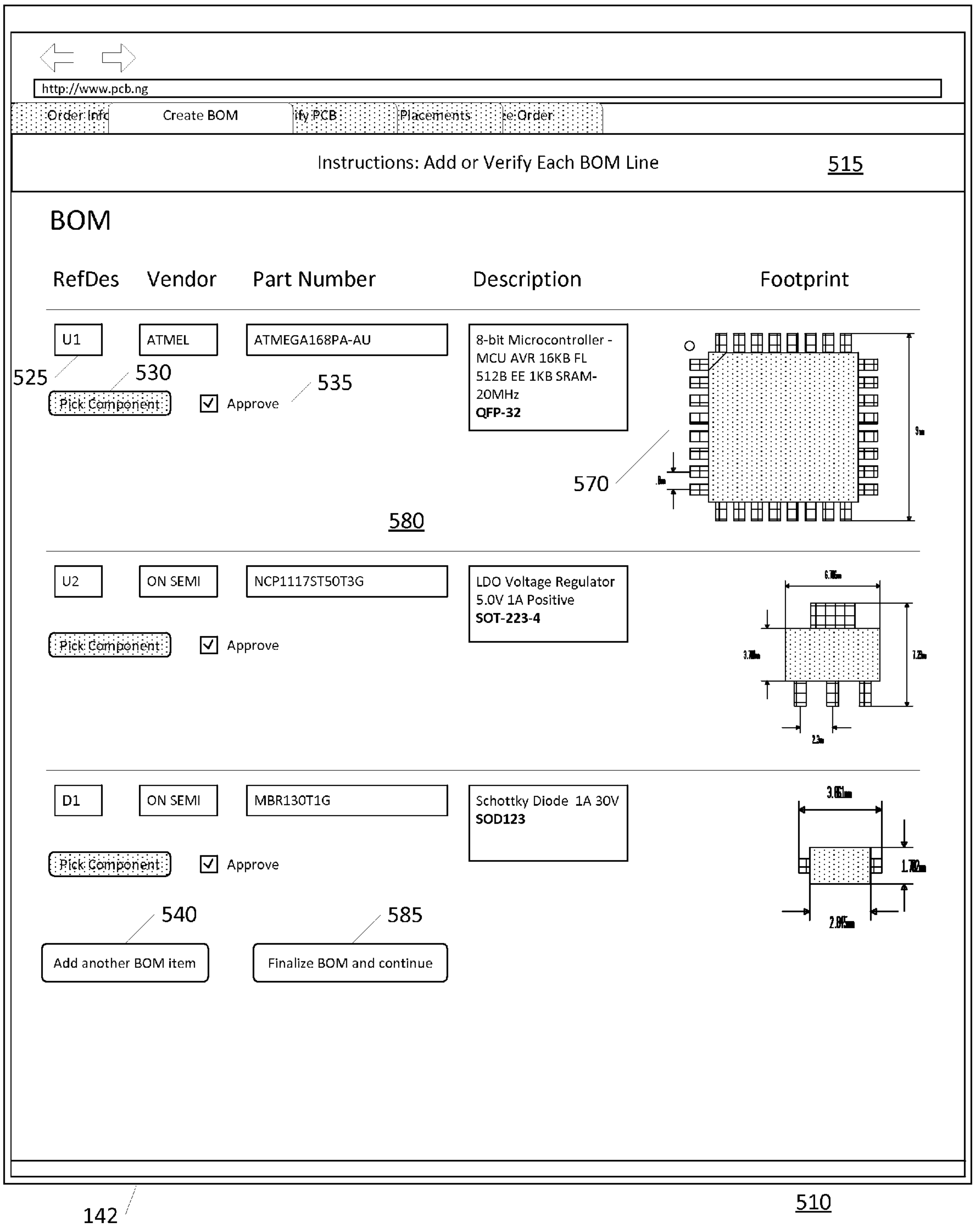
Atmel Atmega 168

Search

Vendor	Part Number	Description	Package	Footprint
ATMEL +Select	ATMEGA168P-20MUR	8-bit Microcontrollers - MCU AVR,16KB FLASH,20MHZ IND TEMP 5V	QFN-28	
ATMEL +Select	ATMEGA168P-20MQ	8-bit Microcontrollers - MCU AVR 4K FLASH 256B EE 20MHZ TEMP GRN 1.8V	QFN-32	
ATMEL +Select	ATMEGA168PA-AU	8-bit Microcontrollers - MCU AVR 16KB FL 512B EE 1KB SRAM-20MHz	QFP-32	

I Require A Different Part/ Footprint

FIG. 5B



Instructions: Add or Verify Each BOM Line

BOM

RefDes	Vendor	Part Number	Description	Footprint
U1	ATMEL	ATMEGA168PA-AU	8-bit Microcontroller - MCU AVR 16KB FL 512B EE 1KB SRAM-20MHz **QFP-32**	
☑ Approve				
U2	ON SEMI	NCP1117ST50T3G	LDO Voltage Regulator 5.0V 1A Positive **SOT-223-4**	
☑ Approve				
D1	ON SEMI	MBR130T1G	Schottky Diode 1A 30V **SOD123**	
☑ Approve				

FIG. 5C

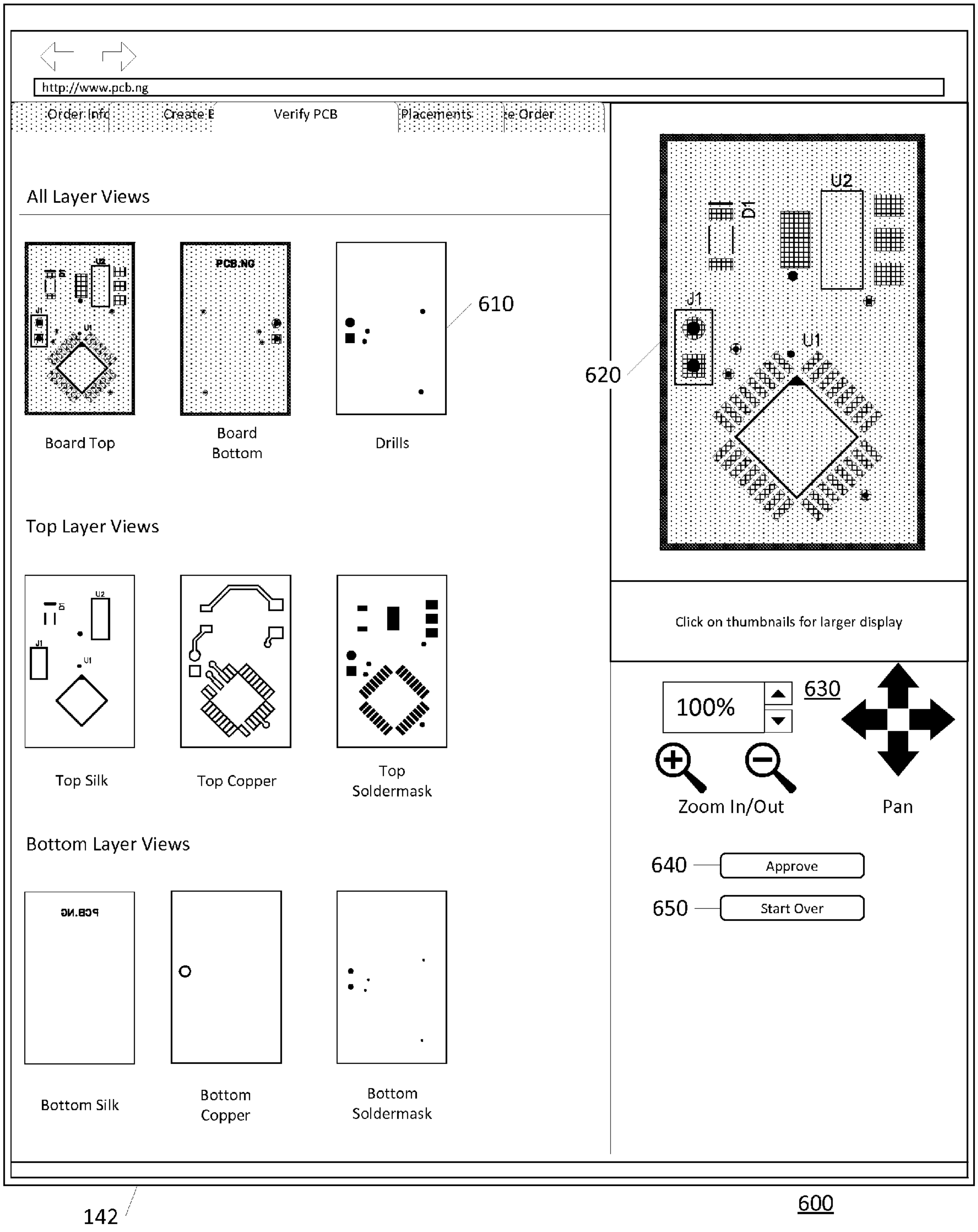
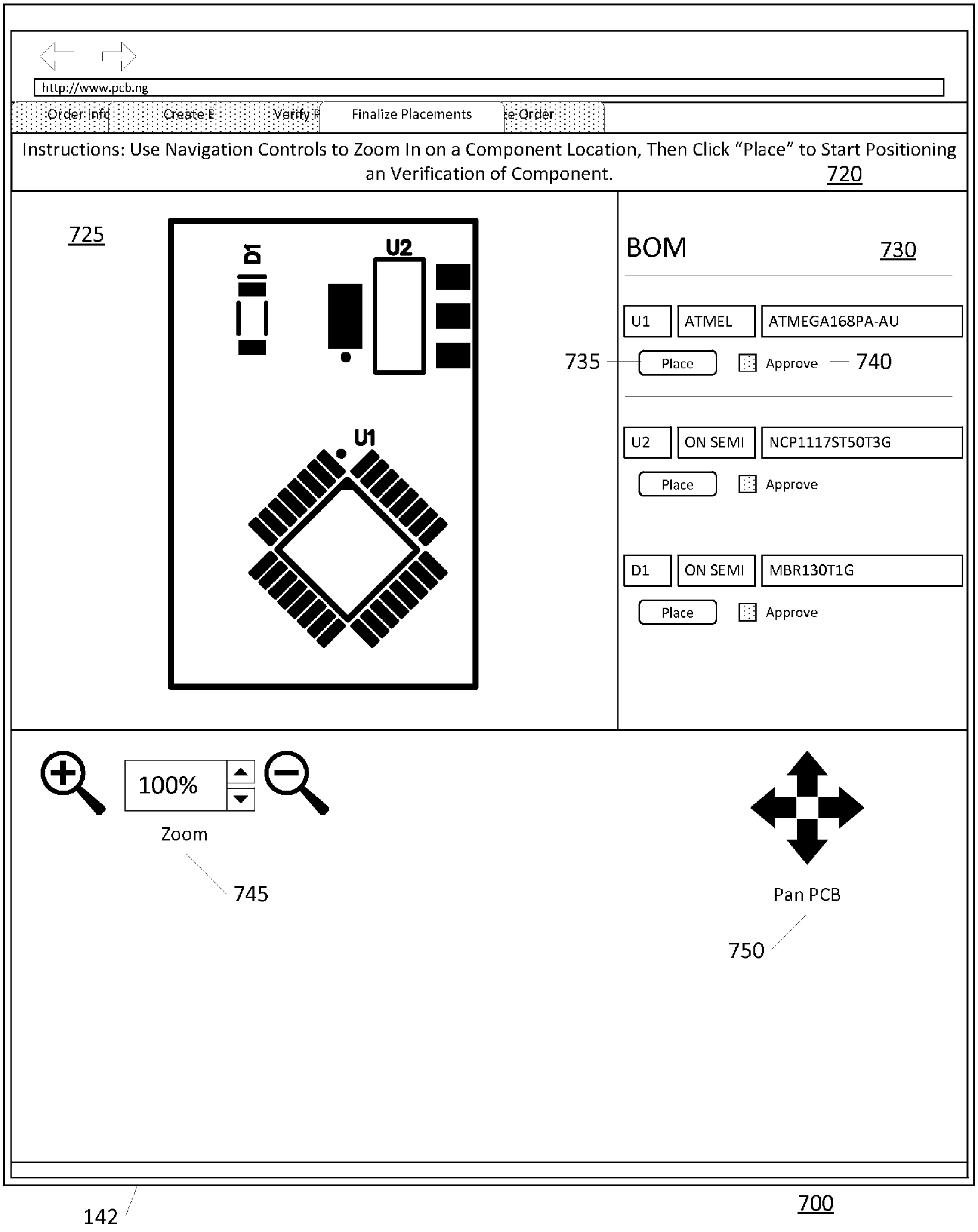

http://www.pcb.ng
Order Infc
Create E
Verify PCB
Placements
te Order
All Layer Views
U2
PCB.NG
610
Board Top
Board Bottom
Drills
Top Layer Views
Top Silk
Top Copper
Top Soldermask
Bottom Layer Views
PCB.NG
Bottom Silk
Bottom Copper
Bottom Soldermask
U2
D1
J1
U1
620
Click on thumbnails for larger display
100%
630
Zoom In/Out
Pan
640
Approve
650
Start Over
142
600

FIG. 6



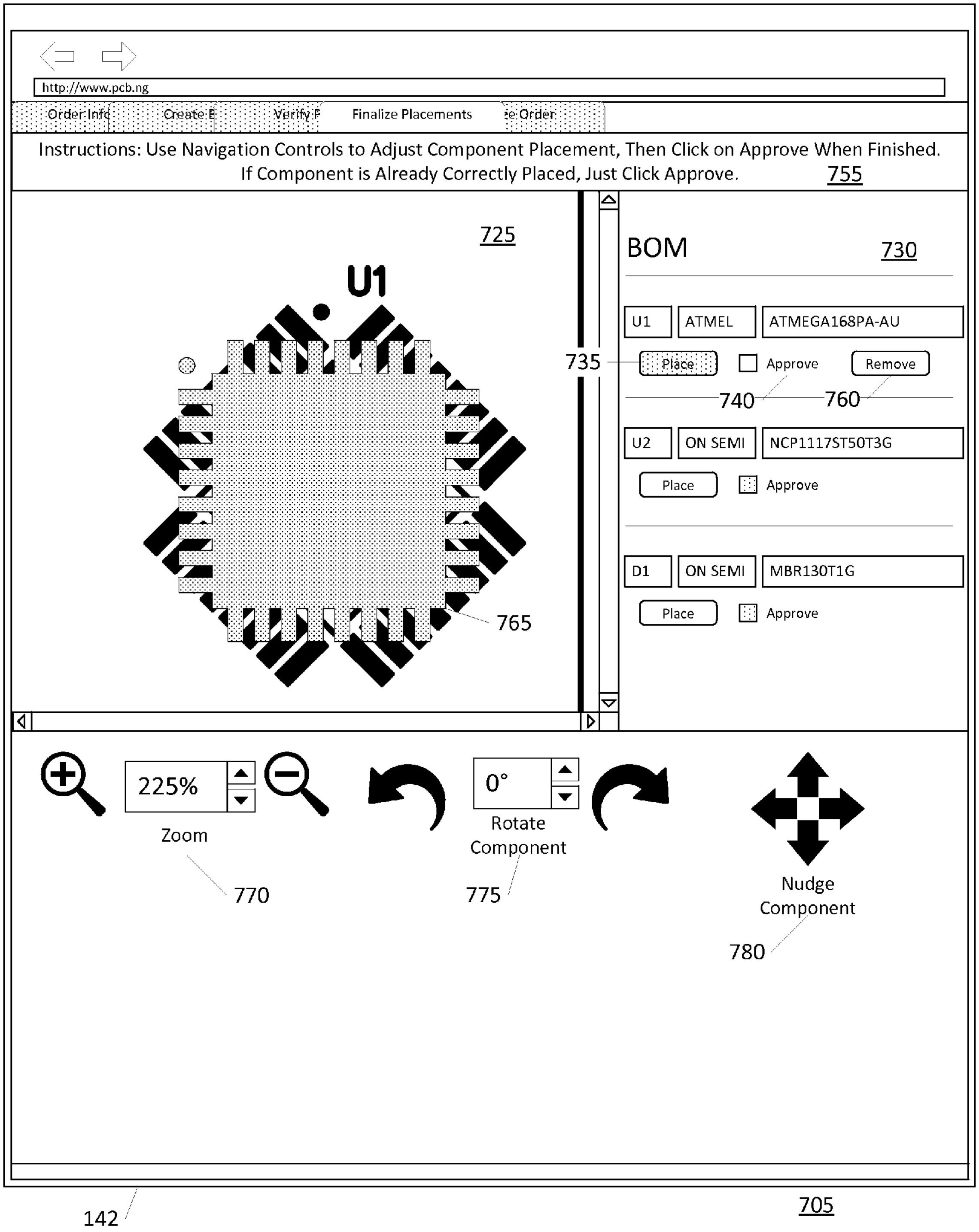
http://www.pcb.ng

Instructions: Use Navigation Controls to Zoom In on a Component Location, Then Click “Place” to Start Positioning an Verification of Component.

BOM

U1	ATMEL	ATMEGA168PA-AU
U2	ON SEMI	NCP1117ST50T3G
D1	ON SEMI	MBR130T1G

FIG. 7A



http://www.pcb.ng

Instructions: Use Navigation Controls to Adjust Component Placement, Then Click on Approve When Finished.
If Component is Already Correctly Placed, Just Click Approve.

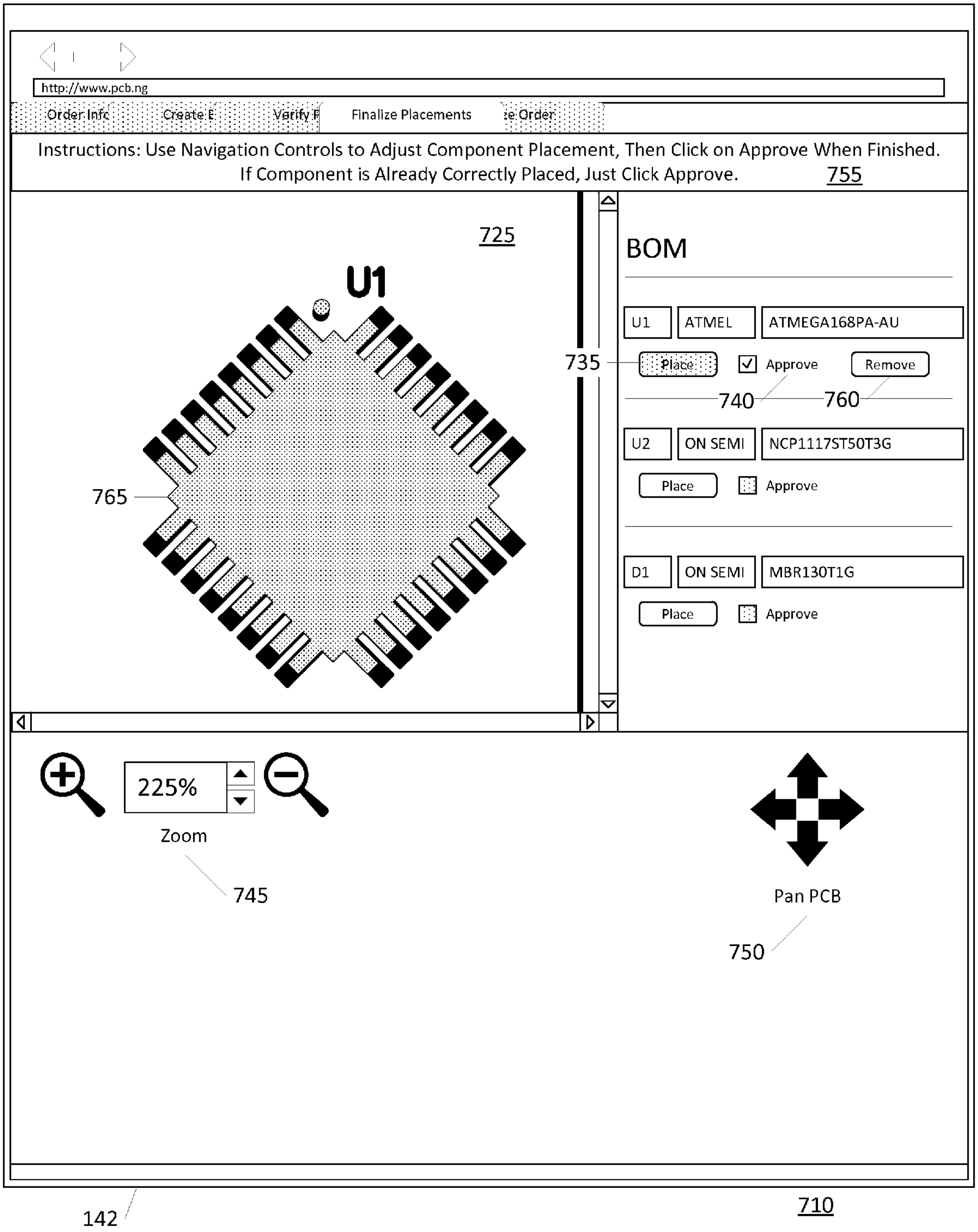
BOM

U1	ATMEL	ATMEGA168PA-AU
U2	ON SEMI	NCP1117ST50T3G
D1	ON SEMI	MBR130T1G

Zoom: 225%

Rotate Component: 0°

FIG. 7B



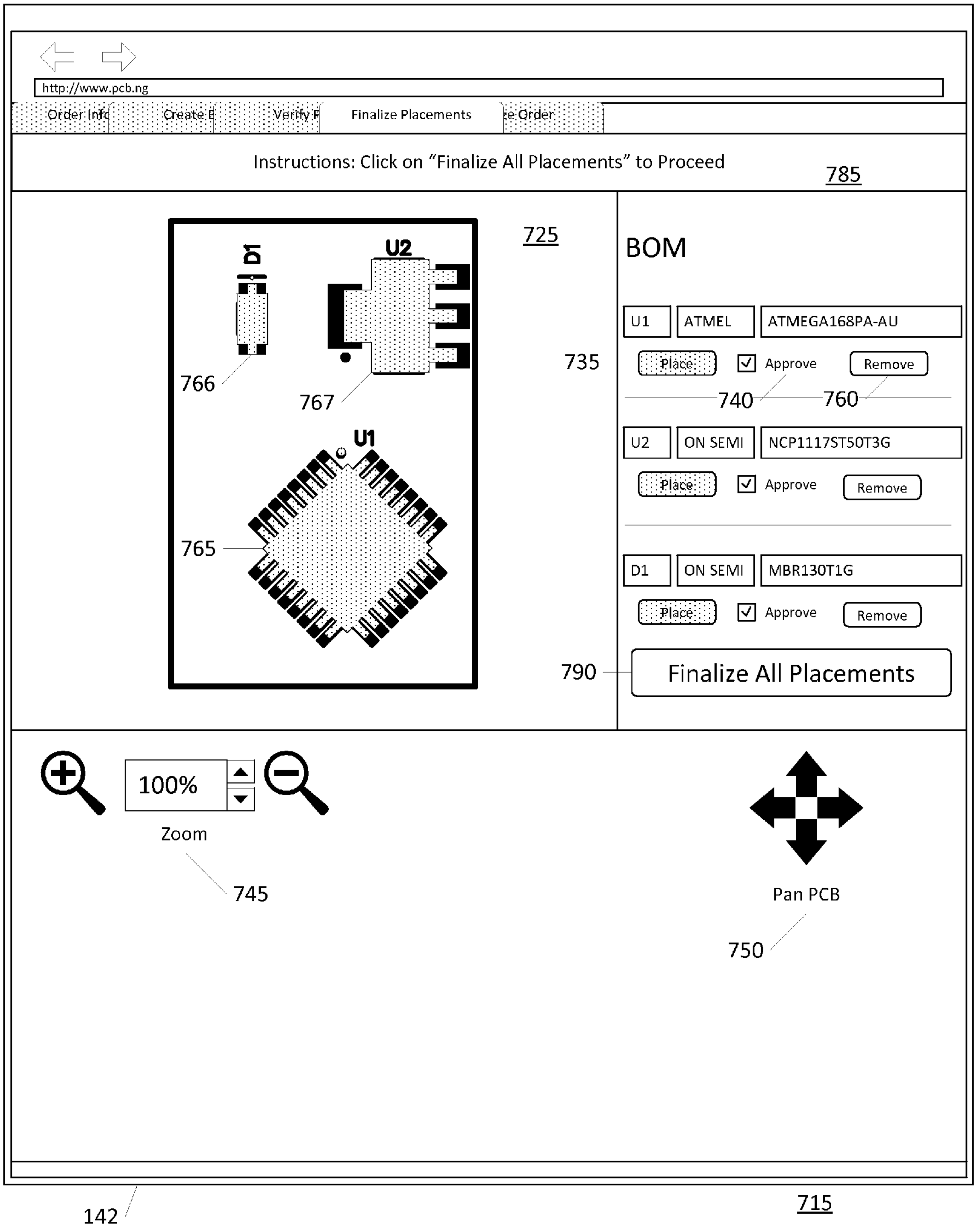
http://www.pcb.ng

Instructions: Use Navigation Controls to Adjust Component Placement, Then Click on Approve When Finished. If Component is Already Correctly Placed, Just Click Approve.

BOM

U1	ATMEL	ATMEGA168PA-AU
U2	ON SEMI	NCP1117ST50T3G
D1	ON SEMI	MBR130T1G

FIG. 7C


http://www.pcb.ng

Order Infc | Create E | Verify F | Finalize Placements | ze Order

Instructions: Click on “Finalize All Placements” to Proceed

BOM

U1	ATMEL	ATMEGA168PA-AU

Place ☑ Approve Remove

U2	ON SEMI	NCP1117ST50T3G

Place ☑ Approve Remove

D1	ON SEMI	MBR130T1G

Place ☑ Approve Remove

Finalize All Placements

100% Zoom

Pan PCB

FIG. 7D

METHOD AND SYSTEM FOR VERIFYING PRINTED CIRCUIT BOARD DESIGNS, AND CREATING OR VERIFYING RELATED ELECTRONIC COMPONENT PLACEMENT DATA FOR PRINTED CIRCUIT BOARD FABRICATION AND ASSEMBLY

BACKGROUND

[0001] Printed circuit board ("PCB") designs can be created and/or edited employing electronic design automation software ("EDA") such as ALTIUM DESIGNER®, CADSOFT EAGLE PCB®, or KICAD. PCB designs are typically stored as digital files residing on a storage medium of a computer (for example, a hard drive). EDA software can also translate PCB design data to industry-standard digital formats, most commonly in RS-274X Gerber format accompanied by Excellon formatted files for drilling-related data. A PCB design may be described by a collection of such files, and such a collection is typically referred to as the "Gerbers" or "the Gerber files" for that design. RS-274X Gerber and Excellon format files are well defined, documented and standardized.

[0002] Some EDA software may also allow the user to export additional data, such as the components included in the bill of materials of the finished design ("BOM"), and the coordinate and orientation data required to physically place electronic components on a PCB (variously referred to as "XYRS" (XY Rotation and Side), "Centroid" and "Pick And Place" files). Unlike RS-274X and Excellon files, there is no standardization or canonical definition of BOM and XYRS files.

[0003] When a customer wishes to have a PCB created by a PCB fabricator, or to purchase PCB assembly (i.e., the placement and fixation of electronic components upon a PCB) services ("PCBA"), the customer need not physically transport various files to a PCB fabricator or PCBA vendor and instead can electronically transmit the files to an "online" vendor using a computer network such as the Internet. For example, the customer can use an Internet browser program (referred to herein as the "user-agent") such as INTERNET EXPLORER® or MOZILLA FIREFOX®. The customer can direct the user-agent to an Internet-connected server associated with the vendor and upload the design data to that server. The vendor can take the design data and create PCBs and/or assemble components upon finished PCBs. In some cases, customers may use a delivery service such as the UNITED STATES POSTAL SERVICE to deliver previously finished PCBs to a PCBA vendor for assembly services.

[0004] In recent years, there has been a tremendous proliferation of computers connected to a global network known as the Internet. The Internet provides a transport mechanism through standardized communication protocols, such as the Hypertext Transport Protocol (HTTP), for communicating web content in the form of text, graphics, sounds, animations, video, and computer executable code.

[0005] An internet browser is a client application or operating system utility that communicates with server computers via FTP, HTTP, and Gopher protocols. Examples of popular web browsers include INTERNET EXPLORER®, by Microsoft Corporation, of Redmond, Wash., and FIREFOX™, by Mozilla Corporation, of Mountain View, Calif. Web browsers conventionally receive electronic documents from the network and present them to a user. In addition to being able to display text, web browsers are also typically able to display graphics and other multimedia content (e.g., video, audio, vector graphics, and vector graphic animations). Electronic documents may include text documents, conventional markup documents (e.g. HTML, XML, and others), graphics and other multimedia content, data files, and code that can be executed or interpreted by the web browser or other system components.

[0006] In addition to data and metadata, HTML documents can contain embedded software components containing program code that perform a wide variety of operations. These software components expand the interactive ability of an HTML document's user interface. JAVASCRIPT™ scripts are examples of software components that are embedded in HTML documents. A browser executes such software components as it reaches the position in the script during interpretation of the HTML document. Scripts loaded during interpretation of the document may modify the document if the browser supports dynamic HTML (DHTML). Scripts may respond to user activity (pointer events or keyboard events), may post data to the server, and may request and receive data from the server. In recent years, Graphical User Interfaces (GUIs) have been implemented inside of web browsers using software embedded in electronic documents and transmitted from server to client over the Internet. Such mechanisms can, for example, use JAVASCRIPT and DHTML capabilities, and are well understood by those skilled in the art.

[0007] XYRS files may reference data variously known as "footprint," "land pattern" or "component" data and generally may specify where the centroid of a land pattern may be placed. Footprint data describes, at the least, the geometry and physical center of an electronic component. Footprint data may be derived from a variety of sources. In some cases, footprint data may be created by the electronic component vendor, the user of the EDA software, or the creator of the EDA software. In some cases, footprint data may be derived from other users, for example, via electronic communities, file-sharing sites, or other "crowdsourcing" methods.

[0008] PCBA vendors also use footprint data in their production processes. This data may be created by the PCBA vendor, or by the manufacturer of the PCBA production equipment, or purchased from a specialized data provider, or a combination of all three. It is not unlikely that a PCBA vendor's footprint data will not match a customer's footprint data for a given component.

[0009] XYRS data does not include component geometry, aside from the physical center of an electronic component which may be derived from land pattern data from EDA software.

[0010] As described above, PCB design files can be uploaded to an online PCBA service. However, the XYRS files are often faulty. Files may be faulty due to the non-standardized nature of XYRS files, or they may incorporate footprint data that, while it may be suitable for certain purposes, is defective for others. For example, footprints with incorrect physical center data will allow for the successful fabrication of PCBs, but not for the successful assembly of the same PCB. In some cases, EDA software does not support creation of an XYRS file. As described above, the footprint data employed by the vendor may differ from that being employed by the user. Unfortunately, the lack of common XYRS files, the lack of a generally accepted file formats, the differences between user and vendor footprint data, and the high defect rates associated with XYRS data often requires

PCBA vendors to manually create, or re-create, XYRS data from the PCB itself (a process called "footprinting" or "teach-in"). For most PCBA vendors, the lack of reliable XYRS data is so common that manual footprinting is an established routine, and user XYRS data is either discarded or not accepted.

[0011] As described above, PCB design files can be uploaded to an online PCBA service. Again, as with the XYRS files, BOM files are often faulty. Files may be faulty due to the non-standardized nature of BOM files, or in the case of customers providing their own components to a PCBA vendor, the actual components may not match the information in the BOM file.

[0012] From the perspective of the PCBA vendor, this lack of predictably reliable XYRS and BOM data is not desirable. Predictably reliable XYRS data would allow a vendor to greatly automate the assembly process, improving profitability and delivery times, but the issues with XYRS data, as described above, means that most vendors find it more efficient to perform manual footprinting. Footprinting is performed on the same equipment that is more profitably used for actual PCBA production, and due to the manual nature of footprinting, may introduce production errors. Unreliable BOM data also increases the potential for errors, and increases support costs for the vendor.

[0013] From the perspective of the PCBA service customer, this lack of reliable XYRS and BOM data increases their costs and lead-time to receive finished product, and increases the likelihood of errors. Additionally, it may also increase their labor costs, as faulty data may be returned to the customer by the PCBA vendor for review and correction.

[0014] The present inventors have recognized that it would be advantageous to provide users with a way to order PCBA services that disallows the possibility of submitting faulty XYRS and BOM data. What is desired is a system that provides the tools and features required for a user to both upload their PCB design data, and to verify and/or input XYRS and BOM data visually. In addition, the system should allow users to associate components in the users' BOM with verified footprint data from a single source, and use the same footprint data for visual verification or creation of XYRS data.

SUMMARY

[0015] Accordingly, the disclosed embodiments are directed to providing a system which can load printed circuit board design data onto a server for purposes of fabricating and assembling printed circuit boards.

[0016] The disclosed embodiments are also directed to allowing the creation of a listing of components, sometimes referred to as a bill of materials, for inclusion in the assembly of printed circuit boards.

[0017] The disclosed embodiments are further directed to allowing the creation of component positioning data, sometimes referred to as XYRS data, for use in the assembly of printed circuit boards.

[0018] Other objects will be obvious and will appear hereinafter. The disclosed embodiments are at least directed to providing an article of manufacture as exemplified in the following summary and detailed description.

[0019] The disclosed embodiments are directed to a system and method for processing electronic PCB design data and associated user input as part of an online ordering system. The system comprises at least one server computer connected to a network. The server is adapted to receive electronic PCB design data and associated user input from a second computer connected to the network. The server processes the electronic PCB data and creates a display containing at least a portion of the processed electronic PCB data. The data representing the display is in a format that allows for transmission to and viewing on a client computer. Viewing on the client computer is preferably accomplished with a graphical user-agent such as a web browser. The server is also adapted to send notifications regarding an order process to at least one person via the network.

[0020] Data for processing electronic PCB design data may also be provided in part from a database containing geometries for electronic components to be employed in PCB assembly.

[0021] The disclosed embodiments are also directed to a system for printed circuit board assembly including a user interface provided on a display device for visual verification of printed circuit board design data, a user interface provided on the display device for inputting bill of material information, and a user interface provided on the display device for verification, alteration and creation of component placement data.

[0022] According to some aspect of the disclosed embodiments, the user interface for visual verification of printed circuit board design data includes an image map of a printed circuit board design, and navigation controls for creating zoomed and panned views of the image map, for reviewing and approving the printed circuit board design.

[0023] In some aspects of the disclosed embodiments, the image map includes a visual representation of the printed circuit board design and each layer of the printed circuit board design as will be manufactured.

[0024] In certain aspects of the disclosed embodiments, the image map is created from a transformation matrix determined from a coordinate system derived from the printed circuit board design data and characteristics of the user interface for visual verification of printed circuit board design data.

[0025] In at least one aspect of the disclosed embodiments, the user interface for inputting bill of material information includes a display for inputting the bill of material information, a display for searching for components to be added to the bill of material information, and a display for showing a visual representation of each component.

[0026] In one or more aspects of the disclosed embodiments, the user interface for verification, alteration and creation of component placement data includes an image map of a printed circuit board design, and a control for adding at least one footprint sprite overlay to at least a portion of the image map.

[0027] In some aspects of the disclosed embodiments, the user interface for verification, alteration and creation of component placement data includes an image map of a printed circuit board design, and controls for adjusting a rotation and coordinates of a footprint sprite overlay on the image map.

[0028] In certain aspect of the disclosed embodiments, the user interface for verification, alteration and creation of component placement data includes an image map of a printed circuit board design, and a control for approving a footprint sprite overlay on the image map as being correctly positioned.

[0029] The disclosed embodiments are further directed to a method including providing a user interface on a display device for visual verification of printed circuit board design data, providing a user interface on the display device for inputting bill of material information, and providing a user interface on the display device for verification, alteration and creation of component placement data.

[0030] Some aspects of the disclosed embodiments include displaying an image map of a printed circuit board design in the user interface for visual verification of printed circuit board design data, and creating zoomed and panned views of the image map, for reviewing and approving the printed circuit board design.

[0031] Other aspects of the disclosed embodiments are directed to including a visual representation of the printed circuit board design and each layer of the printed circuit board design as will be manufactured within the image map.

[0032] Certain aspects of the disclosed embodiments include creating the image map from a transformation matrix determined from a coordinate system derived from the printed circuit board design data and characteristics of the user interface for visual verification of printed circuit board design data.

[0033] At least one aspect of the disclosed embodiments includes using the user interface for inputting bill of material information for inputting the bill of material information, searching for components to be added to the bill of material information, and showing a visual representation of each component.

[0034] One or more aspects of the disclosed embodiments include using the user interface for verification, alteration and creation of component placement data for displaying an image map of a printed circuit board design, and adding at least one footprint sprite overlay to at least a portion of the image map.

[0035] Some aspects of the disclosed embodiments provide for using the user interface for verification, alteration and creation of component placement data for displaying an image map of a printed circuit board design, and adjusting a rotation and coordinates of a footprint sprite overlay on the image map.

[0036] Additional aspects of the disclosed embodiments include using the user interface for verification, alteration and creation of component placement data for displaying an image map of a printed circuit board design, and approving a footprint sprite overlay on the image map as being correctly positioned.

[0037] The above mentioned objectives of the disclosed embodiments will become more apparent and the embodiments themselves better understood with reference to the following description in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] The accompanying drawings, which are included to provide further understanding and are incorporated in and constitute a part of this specification, illustrate disclosed embodiments and together with the description serve to explain the principles of the disclosed embodiments. In the drawings:

[0039] FIG. **1** is a block diagram generally representing a computer system into which the disclosed embodiments may be incorporated;

[0040] FIG. **2** is a block diagram of server and client computer as found in FIG. **1**, illustrating a portion of the functions utilized by the disclosed embodiments;

[0041] FIG. **3** is a flowchart generally representing an exemplary process of the disclosed embodiments using the exemplary servers and clients of FIG. **2**;

[0042] FIG. **4** is a flowchart generally representing an exemplary process of the disclosed embodiments using the exemplary servers and clients of FIG. **2**;

[0043] FIGS. **5**A, **5**B, **5**C and **6** are exemplary screenshots related to the process of FIG. **3**; and

[0044] FIGS. **7**A, **7**B, **7**C and **7**D are exemplary screenshots related to the process of FIG. **4**.

DETAILED DESCRIPTION

[0045] It is believed that the disclosed embodiments will be better understood from a consideration of the following description in conjunction with the drawing figure(s).

[0046] In the following detailed description, numerous specific details are set forth to provide a full understanding of the present disclosure. It will be apparent, however, to one ordinarily skilled in the art that the embodiments of the present disclosure may be practiced without some of these specific details. In other instances, well-known structures and techniques have not been shown in detail so as not to obscure the disclosure.

[0047] FIG. **1** is a block diagram generally representing a computer system into which the disclosed embodiments may be incorporated. The architecture **100** includes servers **110** and clients **130** connected over a network **150**. For example and without limitation thereto, the system of the disclosed embodiments can find application in public as well as private networks, such as closed systems, or private company networks.

[0048] FIG. **2** is a block diagram **200** illustrating an exemplary server **110** and client **130** in the architecture **100** of FIG. **1** according to certain aspects of the disclosure. One of many clients **130** and one of many servers **110** are connected over the network **150** via respective communications modules of **138** and **118**. The communications modules **138** and **118** are configured to interface with network **150** to send and receive information, such as data, requests, responses and commands to other devices on the network. The communications modules **138** and **118** can be, for example, modems or Ethernet cards.

[0049] Clients **130** include a processor **132**, the communications module **138**, and a memory **140** that includes a web browser, also referred to as a User Agent **142**. Clients may be any device capable of presenting data, including, but not limited to, computers, cellular telephones, networked television sets, personal digital assistants, etc. The servers **110** can be any device having an appropriate processor **112**, memory **120** and communications capability for hosting application server **124**. The memory **120** generally includes a computer readable medium storing computer readable program code for carrying out and executing the techniques and processes described herein when executed by the processor **112**.

[0050] In at least one of the disclosed embodiments, application server **124** is a system that sends out Web pages in response to Hypertext Transfer Protocol (HTTP) requests from browser **142**. That is, the application server provides the graphical user interface to users in the form of Web pages. The Web pages sent to client **130** would result in graphical interface screens that include various tools to enter information, manipulate graphical objects in the graphical interface, etc.

[0051] Database **114** stores software, geometry data for components, system data, order data, state data and any other data required by the components of the apparatus. The database may be provided, for example, as a database management system, an object-oriented database management system, a relational database management system, a file system, another conventional database package, or a combination of such systems. Further, the database **114** can be accessed via a Structured Query Language (SQL) or other tools known to one of ordinary skill in the art.

[0052] FIG. **3** is a flowchart generally representing an exemplary process of the disclosed embodiments using the exemplary servers and clients of FIG. **2**. The sample process **30** may be performed by a processing logic contained within application server **124**, by browser **142**, or a combination of both. Referring to FIG. **3**, at block **300** a user employing client **130** initiates an order process on server **110**. As part of the order process, at block **302** the user is prompted to upload PCB design files via a notification in browser **142**. In at least one of the disclosed embodiments, the design files are uploaded via a standard Web browser file upload form. The files, received by server **110**, are analyzed at block **304** by application server **124** to determine if the files have the correct format and generally meet various assembly specifications. If, at block **306**, the uploaded files are found to be outside of predetermined acceptance parameters, processing logic may proceed to block **322**, where the user is notified via on-screen message to correct their design files and resubmit, and logic then returns to block **302**.

[0053] If the user's files are found to be within predetermined acceptance parameters, processing logic may proceed to block **308**. At block **308**, the user's design information is stored in database **114**. Processing logic proceeds to block **310**, where the data from the user's uploaded files are converted by application server **124** into graphical representations **610**, **620** (FIG. **6**) of the uploaded PCB design data. These representations may be in raster format (e.g., PNG, JPG), or in vector format (e.g., SVG, PDF), or in multiple formats suitable for display by client browser **142**. Logic proceeds to block **312**, where techniques known to one of ordinary skill in the art are employed to determine the optimal graphical file types for display within client browser **142**. Logic proceeds to block **314** wherein the graphical representations of the user PCB design data are displayed by client **130** as illustrated in exemplary screenshot **600** (FIG. **6**), according to the disclosed embodiments. In block **320**, the user is provided with an opportunity to approve the graphical representations, where the user is presented with option **640** (FIG. **6**) to approve the graphical representation of their PCB design data, or with option **650** (FIG. **6**) to decline and resubmit their PCB design data. If the user declines, processing logic proceeds to block **322**, where the user is notified via on-screen message to correct their design files and resubmit.

[0054] Upon approval by the user, logic proceeds to block **324**, and the user's design file data and image files are stored in database **114**. Logic proceeds to block **326**, and the user is prompted to enter their BOM data, as illustrated in exemplary screenshot **500** (FIG. 5A), according to the disclosed embodiments. In another embodiment, BOM data may be simply submitted as a text file via a simple Web form.

[0055] After the user submits their BOM data, logic proceeds to block **330**. The user's BOM data is compared to electronic component footprint data, i.e., component geometries, and if all items in the user's BOM data do not correspond to existing footprint data previously stored in database **114** (for example, licensed from a footprint vendor, or supplied by component vendors), logic proceeds to block **340**. The user is notified with an on-screen message at block **340**, notifying of a "hold" condition. Logic proceeds to block **342**, and the entire session/data state is stored in database **114**.

[0056] Logic proceeds to block **344**, wherein any missing footprint data is created either manually or automatically. Footprint data created in block **344** is stored in database **114** as logic proceeds to block **345**. Logic then proceeds to block **346**, where the user is notified that their order process may be resumed. In one or more of the disclosed embodiments, this may be via email, on-screen messaging, or other electronic messaging service. The notification may, in at least one embodiment, include a Uniform Resource Location (URL) hyperlink that includes encoded information that corresponds to the state information saved at block **342**. The user may employ such a hyperlink, or other navigational method, to resume the order process in block **349**, having had their order state recreated from data retrieved in block **348** from database **114**.

[0057] Logic proceeds to block **350**, wherein the current BOM and associated footprint data are saved to database **114**. Logic then proceeds to block **352**, where the user is presented with an on-screen option, according to the disclosed embodiments, to either upload XYRS data via Web form, or to proceed without such data. Logic proceeds to block **360**. If the user elected to, and uploaded XYRS data, the files received by server **110** are analyzed at block **370** by application server **124**. If, at block **370**, the uploaded files are found to be outside of predetermined acceptance parameters, processing logic may proceed to block **372**, where the user is notified via on-screen message to correct their XYRS data and resubmit at block **352**, or to elect to proceed without XYRS data. If, at block **370**, the uploaded files are found to be within predetermined acceptance parameters, logic proceeds to block **380**, and the XYRS data is compared to the BOM data submitted at block **326** to ensure that both sets of data correspond in terms of the naming of each electronic component ("Reference Designators"). If both sets of data do not correspond, logic may proceed to block **372**, where the user is notified via on-screen message to correct their XYRS data and resubmit at block **352**, or to elect to proceed without XYRS data.

[0058] If the user, at block **352**, elects to proceed without XYRS data, or if the user submitted XYRS data that was found to be within acceptance parameters at block **370** and matched the Reference Designators at block **380**, logic proceeds to block **390**. XYRS data, if any, is recorded in database **114** at block **390**. Logic then proceeds to block **392**, where the user is presented with a graphical interface that allows for placement, orientation verification, or adjustment of the component placement, as illustrated in exemplary screenshot **700** (FIG. 7A), following an exemplary process represented by sample process **40** (FIG. **4**) according to the disclosed embodiments. If the user, at block **352**, has elected to proceed without XYRS data, in some embodiments, the system may attempt to place the component before proceeding to the graphical interface illustrated by exemplary screenshot **700**.

[0059] FIG. **4** is a flowchart generally representing an exemplary process for verification and/or creation of XYRS data for component placements for PCB assembly using the exemplary servers and clients of FIG. **2**. The sample process **40** may be performed by a processing logic contained within application server **124**, by browser **142**, or a combination of both.

[0060] Referring to FIG. **4**, at block **401**, data previously uploaded by the user (BOM, PCB design and, if the user elected at block **350** (FIG. **3**), XYRS data), as well as footprint data, is retrieved from database **114** and employed by application server **124** to render a GUI that is transmitted to client **130** to create an interface, as illustrated in exemplary screenshot **700** (FIG. 7A). Logic proceeds to block **402**, and the user is presented with components in their BOM displayed as verified or unverified, for example, as a GUI checkbox that is unchecked when a given component is unverified, illustrated by item **740** (FIG. 7A). "Unverified", according to the disclosed embodiments, is defined to mean that the end user has not approved the placement data of a given component.

[0061] Logic proceeds to block **404**, where a coordinate system is derived from the PCB design data stored in database **114**. Such a coordinate system may be created by operations within one or more of the server **110** and user agent **142** (FIG. 2). Logic proceeds to block **405**, where a coordinate system is derived from characteristics of the user agent **142**. Logic proceeds to block **406**, where a transformation matrix is determined from the derived coordinate systems from the PCB design data and User Agent characteristics. At **407**, an image map, derived from the user's PCB design data, is created by application server **124**, employing the transformation matrix created at block **406**, and presented as illustrated by item **725** (FIG. 7A). The image map may, for example, be a single image map, or a scalable vector image corresponding to the transformation matrix and displayed by the browser **142**.

[0062] Logic proceeds to block **410**, wherein application server **124** determines whether XYRS data is present for each component of the user's BOM. If XYRS data is not present, the user is prompted at block **411** to employ an on-screen GUI, as exemplified by status bar **725** (FIG. 7A), using zoom control **745** and pan control **750** (FIG. 7A) to create a zoom view and to indicate a component location as shown in blocks **412** and **413**, respectively. Server application **124** updates the transformation matrix, according to a "zoom factor" and optionally an "offset factor" derived from user input from controls **745** and **750**.

[0063] If XYRS data is present, logic proceeds to block **415**, wherein application server **124** determines an optimal "zoom factor" and an optional "offset factor" based upon the user-submitted coordinates of the first BOM item, and in turn, updates the transformation matrix.

[0064] Logic proceeds to block **421**, where the image map representation of the user PCB design data is refreshed to reflect the updated transformation matrix. Logic proceeds to block **422**, where vector representations of BOM component footprints are created ("sprites"), internally, by application server **124**, using footprint data retrieved at block **420** from database **114**, and from the current transformation matrix.

[0065] Upon user input, such as the user clicking on a "Place" button, as shown in **735** in exemplary screenshot **700** (FIG. 7A), logic proceeds to block **423**. At block **423**, application server **124** transmits the footprint sprite associated with the BOM item associated with the Place button, and presents the footprint sprite as illustrated in **765** in exemplary screenshot **705** (FIG. 7B). Logic proceeds to block **424**, where the user is prompted to verify the selected component placement via the "Approve" control, as shown in **760** in exemplary screenshot **705** (FIG. 7B). If the user does not verify the placement, logic proceeds to block **431**, wherein the user may use on-screen GUI controls to adjust the rotation and coordinates of the footprint, as shown in **770**, **775** and **780** in exemplary screenshot **705** (FIG. 7B). If the user does verify the selected component placement via the "Approve" control, logic proceeds to block **440**.

[0066] At block **440**, the current component placement data is analyzed by application server **124**. If the current component placement data is found to be outside of predetermined acceptance parameters, processing logic may proceed to block **441**, where the user is notified via on-screen message to correct their component placement. If the user is unable to correct the improper placement as shown in block **433**, logic proceeds to block **326** in FIG. **3**, where the user may enter the selected component again. If the user is able to correct the improper placement as shown in block **433**, logic then returns to block **431**. If the current component placement data is determined to be within predetermined acceptance parameters, logic proceeds to block **442**.

[0067] At block **442**, the coordinates and orientation of the current component placement are retrieved from User Agent **142** by application server **124**. This data is translated back to the original PCB design coordinate system at block **443** using the current transformation matrix. This re-translated coordinate data, and the orientation data, is either written to, or altered in database **114**, and marked as verified at block **444**. Logic then proceeds to block **450**.

[0068] At block **450**, all components verification status in the user's BOM are queried by application server **124** in database **114**. If any components are still marked as unverified, logic passes back to block **410**. If all components are marked as verified, logic proceeds to block **451**.

[0069] At block **451**, the GUI that is transmitted to client **130** by application server **124** is altered to prompt the user to finalize all component placements, as shown in **790** in exemplary screenshot **715** (FIG. 7D). If the user elects to finalize all component placements, the user is then presented with an interface to finalize payment and shipping arrangements for assembled PCBs based on the system and process of the disclosed embodiments.

[0070] FIG. **5**A illustrates an exemplary screenshot **500** of client user agent **142** of a user interface employed for input of BOM data. Status bar **515** may contain various instructional messages at different stages of the entry process. A component section **520** is displayed for each component listed in user submitted XYRS data; in the case of the user not submitting XYRS data, only one section would be initially appear, and the user may add additional sections by adding them via button **540** according to the disclosed embodiments. Entry field **525** may be pre-populated with component reference designators ("Ref Des") in the case of submitted XYRS data, or the field may be manually populated by the user. In one embodiment, button **530** may be employed to initiate a component search. An approval control **535** is visible but not selectable until a component has been selected by the user.

[0071] FIG. **5**B illustrates an exemplary screenshot **505** of client user agent **142** of a user interface employed for visually and textually searching for an electronic component for purposes of BOM data entry. Status bar **545** may contain various instructional messages at different stages of the search/entry process. Entry field **550** may, according to the disclosed embodiments, allow the user to either select an existing RefDes in the case of user submitted XYRS data, or to enter a new Ref Des entirely. Search controls **555** may include a text entry field and a button for initiating a search on data stored in database **114**, by application server **124**. Results sections **560** are displayed for each result from the user search, and populated with pertinent data, as well as a visual representation **570** of each component found. According to the disclosed embodiments, visual representation **570** is derived from the same foot print data stored in database **114** as referenced previously. Each section **560** also contains a "Select" button, which selects a given search result for inclusion in the user BOM. In the case of there being no correct search result for the end-user, button **575** may be employed to request additional parts or footprints for inclusion in the user BOM.

[0072] FIG. **5**C illustrates an exemplary screenshot **510** of client user agent **142** of a user interface employed for input of BOM data, after multiple components have been selected and approved. As in FIG. **5**A, status bar **515** may contain various instructional messages at different stages of the entry process. A component section **580** is displayed for each component that has been previously selected by the user, and, according to the disclosed embodiments, incorporates visual representation **570**. Again, as in FIG. **5**A, the user may add additional sections by adding them via button **540**. Entry field **525** is not alterable unless approval control **535** is de-selected; likewise, button **530** is also no longer active unless approval control **535** is de-selected. Additionally, button **585** is displayed once all components are marked as approved as illustrated in section **580**.

[0073] FIG. **6** illustrates an exemplary screenshot **600** of client user agent **142** of a user interface employed for providing a visual verification of user-uploaded PCB design data, according to the disclosed embodiments. Graphical representations **610**, created by application server **124**, are displayed of each component layer of user submitted PCB design files, as well as composite graphical representations created by merging component graphical representations together. As a result, the graphical representations show a visual representation of each layer of the PCB as will be manufactured, and the entire PCB as will be manufactured. Graphical representations **610** function as a GUI selection control in client user agent **142**, according to the disclosed embodiments, and opting to select one will result in image map **620**, also created by application **124**, updating to correspond with the user's selection. In one aspect of the disclosed embodiments, navigation controls **630** may be employed by the end user to create zoomed and panned views of image map **620**, allowing the end user to see the graphical representations at a detailed level. Button **640** may be employed by the user to indicate that the graphical representations of uploaded PCB design files are satisfactory; button **650** may be employed for by the user to indicate disapproval, and for navigation to a user agent based upload page to resubmit PCB design files.

[0074] FIG. **7**A illustrates an exemplary screenshot **700** of client user agent **142** of a user interface employed for verification, alteration and creation of XYRS data, for purposes of PCB assembly, according to the disclosed embodiments. Status bar **720** may contain various instructional messages at different stages of the entry process. Buttons **735** are employed to allow the user to add a previously described footprint sprite overlaying image map **725**. Image map **725** functions as previously described **620**; similarly, navigation controls **745** and **750** function similarly to **630** for purpose of zooming and panning image map **725**. Unlike **630**, controls **745** and **750** are modal, in that they may be employed in another aspect to be described later. Approval controls **740** are employed to allow the user to indicate approval of a component position and orientation, and are configured to be visually and functionally enabled once a corresponding footprint sprite overlay is present. BOM area **730** is derived from user submitted BOM data as previously described.

[0075] FIG. **7**B illustrates another functional aspect of exemplary screenshot **700** (FIG. **7**A) where XYRS data existed but is incorrect and requires adjustment. In exemplary screenshot **705** of client user agent **142**, footprint sprite overlay **765** has been added to image map **725** by the user via button **735**. According to the disclosed embodiments, several of the controls previously described are modal in nature. Button **735** is visually and functionally altered such that it is disabled after footprint sprite **765** has been added to image map **725**. Likewise, corresponding approval control **740** is configured to be visually and functionally available to the user. Button **760** is added to user agent **142** GUI, and may be employed by the user to remove footprint sprite overlay **765** from image map **725**.

[0076] Controls **745** and **750** (FIG. **7**A) are altered in user functionality once a footprint sprite overlay is added to image map **725**. They are replaced by controls **770**, **775**, and **780** which may be employed by the user to alter the position and orientation of footprint sprite overlay **765**. This change in functionality is communicated via status bar **755**.

[0077] FIG. **7**C illustrates another functional aspect of exemplary screenshot **700** (FIG. **7**A). In exemplary screenshot **710** of client user agent **142**, footprint sprite overlay **765** has been approved as being correctly positioned by the user via approval control **740**. Controls **770**, **775**, and **780** (FIG. **7**B) are altered in user functionality once the position of a footprint overlay **765** has been indicated as correct by the user via approval control **740**, and may be employed as previously described to alter the view of image map **725**.

[0078] FIG. **7**D illustrates another functional aspect of exemplary screenshot **700** (FIG. **7**A). In exemplary screenshot **715** of client user agent **142**, footprint sprite overlays **765**, **766** and **767** have been approved by the user as previously described. Status bar **785** is again updated with new instructions; button **790** is added to user agent **142** GUI, and may be employed by the user to indicate approval of all PCB component positions, including those that have been created or modified, and to submit all XYRS data, including all new and modified data, to application server **124**.

[0079] While the disclosed embodiments have been described with reference to one or more specific embodiments, the description is intended to be illustrative and is not to be construed as limiting. Various modifications may occur to those skilled in the art that, and while not specifically shown herein, would nevertheless be within the scope of the disclosed embodiments.

1. A system for printed circuit board assembly comprising:

a user interface provided on a display device for visual verification of printed circuit board design data;

a user interface provided on the display device for inputting bill of material information; and

a user interface provided on the display device for verification, alteration and creation of component placement data.

2. The system of claim **1**, wherein the user interface for visual verification of printed circuit board design data comprises:

an image map of a printed circuit board design; and

navigation controls for creating zoomed and panned views of the image map, for reviewing and approving the printed circuit board design.

3. The system of claim **2**, wherein the image map includes a visual representation of the printed circuit board design and each layer of the printed circuit board design as will be manufactured.

4. The system of claim **2**, wherein the image map is created from a transformation matrix determined from a coordinate system derived from the printed circuit board design data and characteristics of the user interface for visual verification of printed circuit board design data.

5. The system of claim **1**, wherein the user interface for inputting bill of material information comprises:

a display for inputting the bill of material information;

a display for searching for components to be added to the bill of material information; and

a display for showing a visual representation of each component.

6. The system of claim **1**, wherein the user interface for verification, alteration and creation of component placement data comprises:

an image map of a printed circuit board design; and

a control for adding at least one footprint sprite overlay to at least a portion of the image map.

7. The system of claim **1**, wherein the user interface for verification, alteration and creation of component placement data comprises:

an image map of a printed circuit board design; and

controls for adjusting a rotation and coordinates of a footprint sprite overlay on the image map.

8. The system of claim **1**, wherein the user interface for verification, alteration and creation of component placement data comprises:

an image map of a printed circuit board design; and

a control for approving a footprint sprite overlay on the image map as being correctly positioned.

9. A method comprising:

providing a user interface on a display device for visual verification of printed circuit board design data;

providing a user interface on the display device for inputting bill of material information; and

providing a user interface on the display device for verification, alteration and creation of component placement data.

10. The method of claim **9**, further comprising:

displaying an image map of a printed circuit board design in the user interface for visual verification of printed circuit board design data; and

creating zoomed and panned views of the image map, for reviewing and approving the printed circuit board design.

11. The method of claim **10**, further comprising including a visual representation of the printed circuit board design and each layer of the printed circuit board design as will be manufactured within the image map.

12. The method of claim **10**, further comprising creating the image map from a transformation matrix determined from a coordinate system derived from the printed circuit board design data and characteristics of the user interface for visual verification of printed circuit board design data.

13. The method of claim **9**, comprising using the user interface for inputting bill of material information for:

inputting the bill of material information;

searching for components to be added to the bill of material information; and

showing a visual representation of each component.

14. The method of claim **9**, comprising using the user interface for verification, alteration and creation of component placement data for:

displaying an image map of a printed circuit board design; and

adding at least one footprint sprite overlay to at least a portion of the image map.

15. The method of claim **9**, comprising using the user interface for verification, alteration and creation of component placement data for:

displaying an image map of a printed circuit board design; and

adjusting a rotation and coordinates of a footprint sprite overlay on the image map.

16. The method of claim **9**, comprising using the user interface for verification, alteration and creation of component placement data for:

displaying an image map of a printed circuit board design; and

approving a footprint sprite overlay on the image map as being correctly positioned.

* * * * *