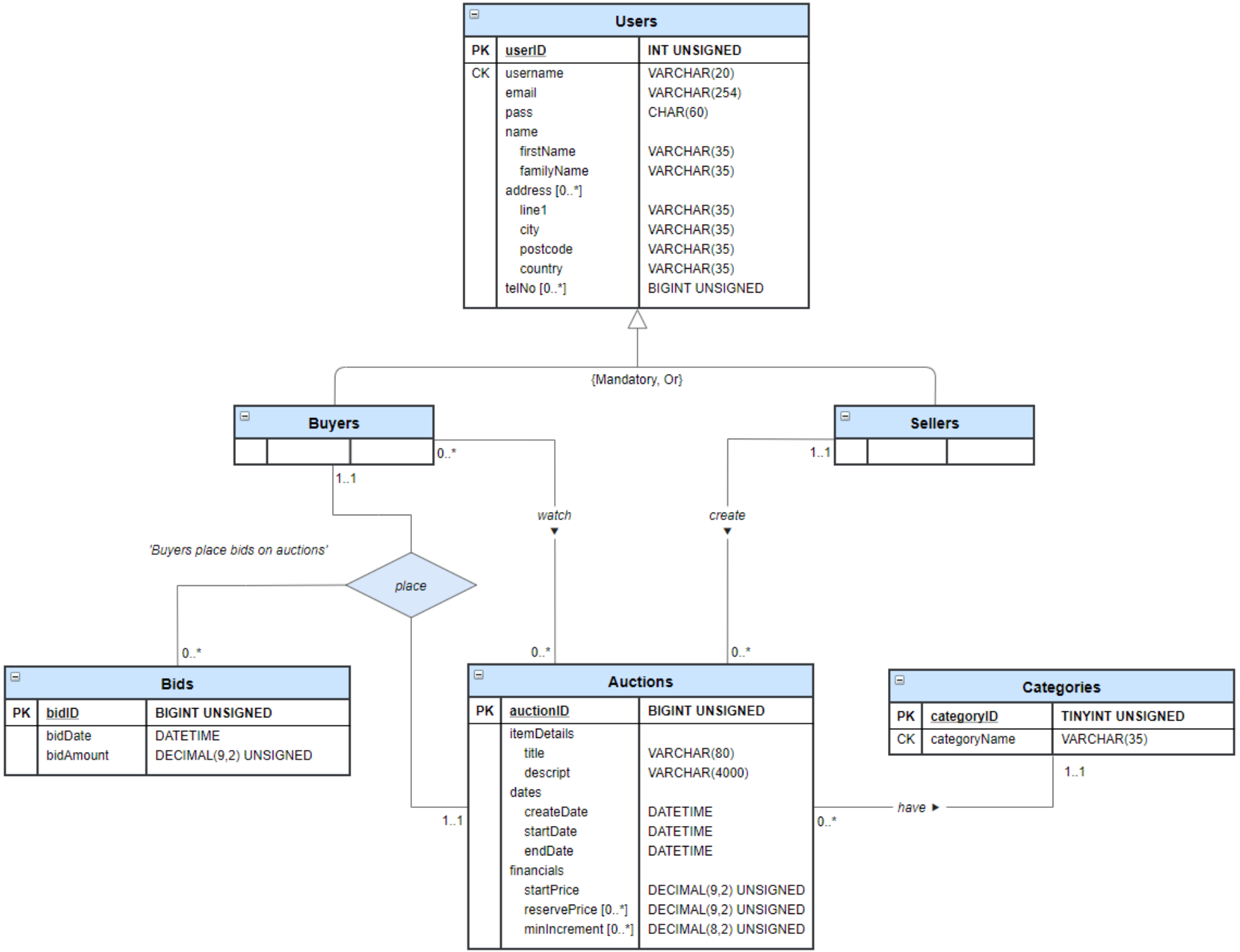
Database design wireframe

1 – **Conceptual design** (building conceptual data model)

- 1.1 - *Identify entity types*
    - Data dictionary documenting entities (or 'entity dictionary')
        - Highlight requirements table
        - At this stage don't have address, telNo or countries as separate entities
- 1.2 - *Identify relationship types*
    - List of entities and relationships e.g. "Sellers create auctions"
        - Highlight requirements table
    - First-cut ER diagram without attributes incl. multiplicity
        - At this point assuming auctions can only have one category (not a big difference in ER diagram, but would make a big difference in the schema); also assuming only one 'parent' level of categories – no sub-categories
    - Check for fan and chasm traps
    - Augmented data dictionary (or 'relationship dictionary')
- 1.3 - *Identify and associate attributes with entity or relationship types in ERD*
    - Discuss logic about attributes chosen:
        - Huge number of possible attributes and associated functionality for an auction site. Focus on those:
            - Necessary for stated functionality (e.g. reservePrice)
            - Simple to include in a complete way (e.g. minIncrement)
            - Necessary in general (e.g. addresses for sellers to post to, and for payment assuming use own payment platform, incl. both billing & shipping addresses.
    - Identify entity and relationship attributes (highlight requirements table)
        - Simple/composite
        - Single/multi-valued
        - Derived. Note here about derived attributes – many are 'natural' and technically not going to break 3NF (later), but generally not a good idea unless clear evidence of a performance advantage since they increase complexity
    - Check only associated with one entity
    - Augmented data dictionary (or 'attribute dictionary')
- 1.4 - *Determine attribute domains*
    - Define domains of each attribute
        - Allowable set of values (e.g. M or F)
        - Sizes and formats (e.g. 1 character)
        - Assuming this platform is designed for scale rather than testing, so allowing lots of users, bids, etc. from the beginning

        - Check phone number, email address and passwords for formatting/requirements before inserting into the database. Phone number stored as DATETIME rather than TIMESTAMP.
        - Possibly better for buyerID/sellerID to be different in format e.g. (Bxx) (Yxx). Not crucial so not implemented here.
    - Add to 'attribute dictionary'
- 1.5 - *Determine candidate, primary, and alternate key attributes*
    - Identify CKs: minimal set of attributes uniquely identifying occurrence of the entity
        - PK: chosen for identification (PPK if composite)
            - Include userID so users can change username easily
            - Include auctionID since allow duplicate titles (need a CK per table) – but note, technically a 'weak' entity
            - Include categoryID so category name can be changed (e.g. to superset); possibly shorter
            - Include bidID so have a shorter identifier (than incl. buyers, auctions) – but note, technically a 'weak' entity
        - AK: other CKs (NB: allow titles to be non-unique)
            - username
            - categoryName
    - Select based on size, probability of values being changed, shortest length or easiest to use
    - Add to data dictionary
    - At this stage, also identify strong and weak entities
        - *Strong:* can assign a primary key to the entity
        - *Weak:* cannot identify a primary key to the entity. PK of weak entity can be identified only once we've mapped the weak entity and its relationship with its 'owner' entity' to a relation through placement of a foreign key in the relation.
- 1.6 - *Consider use of enhanced modelling concepts (optional step)*
    - Specialisation/generalization (specific instance of the parent). Done here for buyers & sellers
    - Aggregation (child can exist independently of parent)
    - Composition (child cannot exist independently of parent)
- 1.7 - *Check model for redundancy*
    - Remove redundant entities
        - Re-examine 1:1 relationships (i.e. don't have two entities representing same object)
    - Remove redundant relationships
        - i.e. don't have relationship where same information can be gained via other relationships, as developing a minimal data model.
- 1.8 - *Validate conceptual data model against user transactions*
    - Some examples of 'written' transactions (like SQL queries) and show how they are possible
- 1.9 - *Review conceptual data model with user*
    - Received feedback on week 3 draft of ER diagram in week 4


Users
PK
userID
INT UNSIGNED
CK
username
VARCHAR(20)
email
VARCHAR(254)
pass
CHAR(60)
name
firstName
VARCHAR(35)
familyName
VARCHAR(35)
address [0..*]
line1
VARCHAR(35)
city
VARCHAR(35)
postcode
VARCHAR(35)
country
VARCHAR(35)
telNo [0..*]
BIGINT UNSIGNED
{Mandatory, Or}
Buyers
Sellers
0..*
1..1
1..1
watch
create
'Buyers place bids on auctions'
place
0..*
0..*
0..*
Bids
PK
bidID
BIGINT UNSIGNED
bidDate
DATETIME
bidAmount
DECIMAL(9,2) UNSIGNED
Auctions
PK
auctionID
BIGINT UNSIGNED
itemDetails
title
VARCHAR(80)
descript
VARCHAR(4000)
dates
createDate
DATETIME
startDate
DATETIME
endDate
DATETIME
financials
startPrice
DECIMAL(9,2) UNSIGNED
reservePrice [0..*]
DECIMAL(9,2) UNSIGNED
minIncrement [0..*]
DECIMAL(8,2) UNSIGNED
1..1
0..*
have
Categories
PK
categoryID
TINYINT UNSIGNED
CK
categoryName
VARCHAR(35)
1..1

2 – **Logical design** (building logical data model)

- 2.1 - *Derive relations for logical data model*
    - Superclass/subclass
        - {Mandatory, Or} so create one relation each for buyers and sellers, no Users relation
        - Having combined would be an option (with a 'type') and makes some querie/DB structure more straightforward
        - Depends on whether site plans to combine roles in the future or not – assume not (e.g. only want 'real' registered businesses as sellers, more like Amazon)
    - *1NF:*
        - Flatten composite attributes
        - No nulls – if optional, separate entity
            - Address, telNo need separate entities
                - Include addressID as PK to reduce data duplication, possibly shorter. No need for telNo as only one attribute in entity.
                - Likewise, can include a country entity since this is a fixed list (and can be used on the front-end). Have a countryID PK to reduce data duplication (shorter) and in case countries change names (does happen occasionally)
                - For addresses and telNos, treat these as a 1:* rather than *:* relationship – *see notes*. Therefore need separate 'buyer' and 'seller' entities for both of these (since FK can't reference two entities at once).
            - reservePrice, minIncrement can be handled on the DB and PHP side by setting these to 'startPrice' and '0.01' respectively if null, so no separate entities needed
    - Other strong entities (create a relation + flatten composite attributes)
        - Categories
    - Weak entities (create a relation + flatten composite attributes; PK already identified)
        - Bids
        - Auctions
    - 1:* relationships ("1" side is designated parent and "*" side gets PK of parent as an FK)
        - Users (buyers/sellers) (1) have addresses (*) and telephone numbers (*)
        - Addresses (buyer/seller) (*) have countries (1)
        - Sellers (1) *create* auctions (*)
        - Auctions (*) *have* categories (1)
    - *:* relationships (create a relation to represent the relationship incl. PKs of both entities participating as FKs and any other relevant attributes; one or both of FKs acts as PK)
        - Buyers (*) *watch* auctions (*)
    - Complex relationship types (create a relation representing the relationship incl. attributes part of the relationship, favouring PK of entity with 'many' cardinality near it)
        - Buyers (1) place bids (*) on auctions (1)

- NB: This will just create a dedicated table as an extension of the bids table with FKs from Buyers and Auctions
- Could replicate ER diagram as a visual 'schema', with added FKs and an extra 'Watching' table attached to 'watch' relationship (labelled 'Watching')
- For 'Watching' table, don't add a new PK as not referenced elsewhere, so no advantage in terms of storage saving

- 2.2 - *Validate relations using normalization*
  - Check step-by-step that there are no FDs violating 2NF or 3NF
    - Done – discussion around addresses needed (e.g. for the UK)
      - 4x4 for pairwise checking of quads, triples and doubles etc. for UK; if not true for UK then not true in general
      - Discussion around 'over normalization' and intention
      - Discuss 'null' values and 1NF
    - Can systematically do this as in the book for each relation
- 2.3 - *Validate relations against user transactions*
  - Check actually works for given request manually. Implicitly done this when testing the front-end.
- 2.4 - *Check integrity constraints*
  - Required data – all data (no nulls allowed)
  - Attribute domain constraints – already done earlier
  - Multiplicity – already done earlier;
    - Multiplicity constraints in general reflect understanding of requirements, not a wider range of what could be logically possible (e.g. users can stop an address from being associated from their account, which would imply a 0..* multiplicity, or user accounts can be deleted)
  - Entity integrity – PKs identified, CKs (unique) identified
  - Referential integrity
    - Are FK nulls allowed? No, since no nulls allowed.
    - How to ensure referential integrity? 2x3 of child, parent vs. insert, delete, update – 3 relevant DML functions; only interested in 4 cases (defined after schema listed later in document)
- 2.5 - *Review logical data model with user*
  - Not done as this is an assessment
- 2.6 - *Merge logical data models into global model (optional step)*
  - Skipped as only creating a single user view, but in reality might want to create multiple views for different roles e.g. admin vs. data scientists especially wrt. the creation of the 'Defaults' table
- 2.7 - *Check for future growth*
  - Discussion about extensibility – list of additional features e.g. email verifications, phone verifications, 2FA, primary/secondary/home/mobile, different email and phone number types, images, ratings and how difficult it would be to include

Schema:

Buyers (buyerID, username, email, pass, firstName, familyName)

BuyerAddresses (addressID, line1, city, postcode, *countryID, buyerID)*

BuyerTels (telNo, *buyerID*)

Sellers (sellerID, username, email, pass, firstName, familyName)

SellerAddresses (addressID, line1, city, postcode, *countryID, sellerID)*

SellerTels (telNo, *sellerID*)

Countries (countryID, countryName)

Bids (bidID, bidDate, bidAmount, *buyerID, auctionID*)

Watching (*auctionID*, *buyerID*)

Auctions (auctionID, title, descript, createDate, startDate, endDate, startPrice, reservePrice, minIncrement, *sellerID, categoryID*)

Categories (categoryID, categoryName)

- Referential integrity:
    - On insertion of new record to child relation, check FK value equal to a value of parent tuple
        - Done automatically in MySQL with InnoDB
    - On update of child FK value, check equal to a value of existing parent tuple (done automatically in MySQL with InnoDB)
        - Done automatically in MySQL with InnoDB
    - On update to parent PK value, cascade update to child entities' FK values
        - Need to code as different options here. We want update (though the PK is highly unlikely to change)
    - For deletion, need to think about 1) if want to allow (simpler to just say no for all) and 2) how
    - Allow deletion for all FK parents (except country, as countries are unlikely to change – in event of a country ceasing to exist, can change name to new name and select 'unique' when pulling the list on PHP) even though not included as a feature on UI side currently since may want to delete things directly e.g. inactive accounts, old auctions, redundant categories. On deletion from parent tuple.
        - *** Note: InnoDB does not support ON DELETE, SET DEFAULT, so when it says that below it is actually achieved differently in the code (a combination of a trigger and 'ON DELETE, CASCADE' ***
        - BuyerAddresses *buyerID: cascade*
            - If a buyer is deleted, then no need for address information (since assuming an address can only be held by one buyer)
        - SellerAddresses *sellerID: cascade*
            - If a seller is deleted, then no need for address information (since assuming an address can only be held by one seller)
        - BuyerTels *buyerID: cascade*

        - If a buyer is deleted, then no need for telNo information (since assuming a telNo can only be held by one buyer)

    - SellerTels *sellerID: cascade*
        - If a seller is deleted, then no need for telNo information (since assuming a telNo can only be held by one seller)

    - BuyerAddresses *countryID:* no action
        - Most likely a mistake, other ways to handle this

    - SellerAddresses *countryID:* no action
        - Most likely a mistake, other ways to handle this

    - Bids *buyerID*: set default
        - Mechanism to avoid allowing nulls but keep bid information for completed listing searches. More important to avoid nulls on insertion, since that should always be linked to a buyer (and also for 1NF).
            - *More complex version would only allow deletion if bids are for non-active auctions*

    - Bids *auctionID*: cascade
        - *If an auction is deleted, then no need for bid information*

    - Watching *buyerID :* cascade
        - If a buyer is deleted whilst watching an auction, no need for watching information

    - Watching *auctionID:* cascade
        - If an auction is deleted whilst someone is watching it, no need for watching information

    - Auctions *sellerID:* set default
        - Mechanism to avoid allowing nulls but keep auction information for completed listing searchers. More important to avoid nulls on insertion, since that should always be linked to a seller (and also for 1NF).
            - *More complex version would only allow deletion if auctions are non-active*

    - Auctions *categoryID:* set default
        - *Allow auctions to keep a category (i.e. 'Other'): better to update rather than delete categories but might lead to a strange organisation of categories*
            - But, if not happening in isolation (e.g. also adding new categories), will need to be careful in update

- Default values:
    - Bids *buyerID*: 1 *(N/A)*
    - Auctions *sellerID: 1 (N/A)*
    - Auctions *categoryID: 1 (Other)*

- *To prevent deletion* create an additional 'Defaults' table *which only top-level administrators can access – other normal 'admins' cannot see it as they aren't granted rights on it – that references the above tables with a foreign key constraint. Since most 'action' will relatively be in the bids, sellers and categories tables, this helps to ensure integrity.*
    - The below database scheme diagram is therefore technically missing the 'defaults' table, but omitted for simplicity since not a core part of scheme except maintaining integrity (i.e. contains no information relevant to actual entities and relationships)
    - In a production implementation, might have a portal for DB administrators to interact with DB with its own logic to prevent deletion of certain rows (i.e. only certain records are visible)

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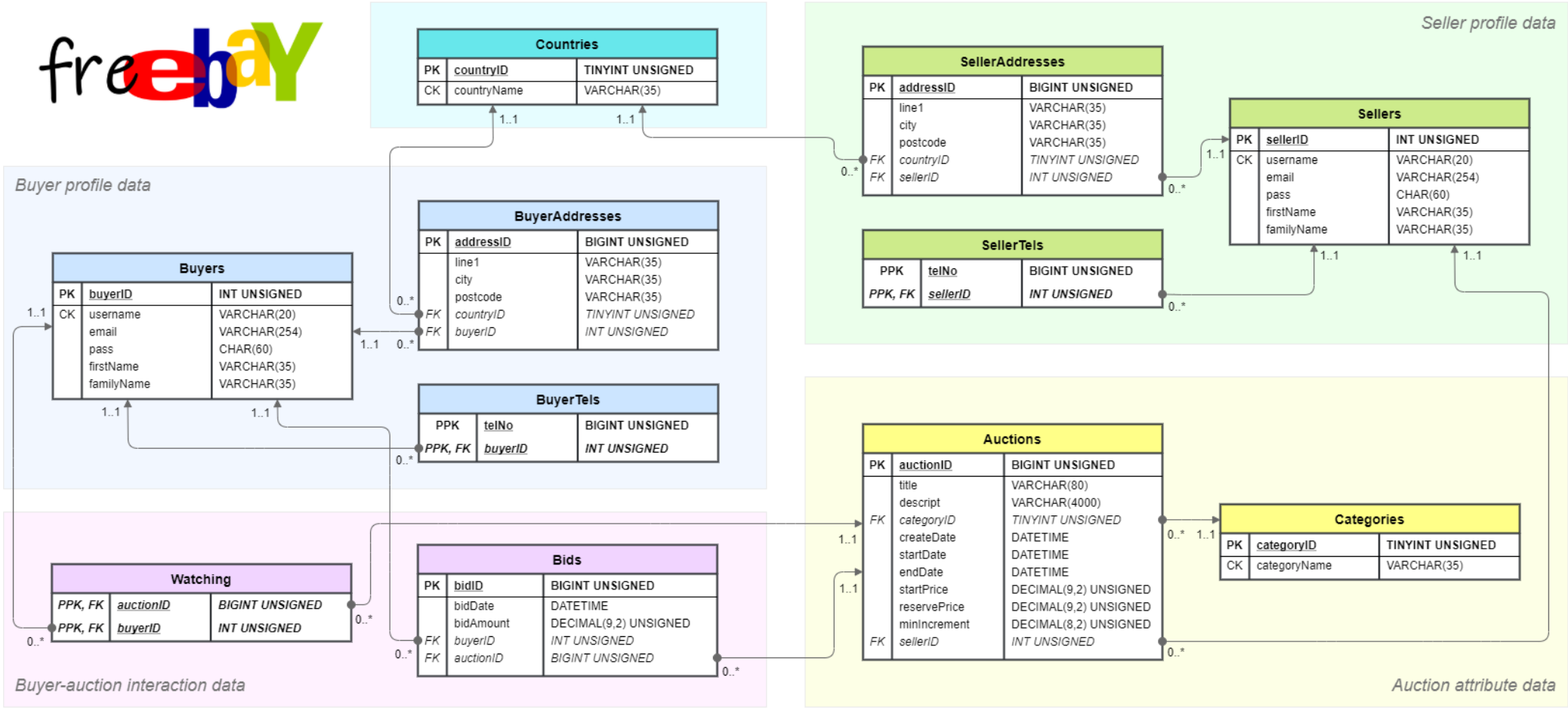
Countries
PK countryID TINYINT UNSIGNED
CK countryName VARCHAR(35)
1..1
1..1
Seller profile data
SellerAddresses
PK addressID BIGINT UNSIGNED
line1 VARCHAR(35)
city VARCHAR(35)
postcode VARCHAR(35)
FK countryID TINYINT UNSIGNED
FK sellerID INT UNSIGNED
0..*
1..1
0..*
Sellers
PK sellerID INT UNSIGNED
CK username VARCHAR(20)
email VARCHAR(254)
pass CHAR(60)
firstName VARCHAR(35)
familyName VARCHAR(35)
1..1
1..1
SellerTels
PPK telNo BIGINT UNSIGNED
PPK, FK sellerID INT UNSIGNED
0..*
Buyer profile data
BuyerAddresses
PK addressID BIGINT UNSIGNED
line1 VARCHAR(35)
city VARCHAR(35)
postcode VARCHAR(35)
FK countryID TINYINT UNSIGNED
FK buyerID INT UNSIGNED
0..*
0..*
Buyers
PK buyerID INT UNSIGNED
CK username VARCHAR(20)
email VARCHAR(254)
pass CHAR(60)
firstName VARCHAR(35)
familyName VARCHAR(35)
1..1
1..1
1..1
BuyerTels
PPK telNo BIGINT UNSIGNED
PPK, FK buyerID INT UNSIGNED
0..*
Auctions
PK auctionID BIGINT UNSIGNED
title VARCHAR(80)
descript VARCHAR(4000)
FK categoryID TINYINT UNSIGNED
createDate DATETIME
startDate DATETIME
endDate DATETIME
startPrice DECIMAL(9,2) UNSIGNED
reservePrice DECIMAL(9,2) UNSIGNED
minIncrement DECIMAL(8,2) UNSIGNED
FK sellerID INT UNSIGNED
1..1
1..1
0..*
Categories
PK categoryID TINYINT UNSIGNED
CK categoryName VARCHAR(35)
1..1
0..*
Watching
PPK, FK auctionID BIGINT UNSIGNED
PPK, FK buyerID INT UNSIGNED
0..*
0..*
Bids
PK bidID BIGINT UNSIGNED
bidDate DATETIME
bidAmount DECIMAL(9,2) UNSIGNED
FK buyerID INT UNSIGNED
FK auctionID BIGINT UNSIGNED
0..*
0..*
Buyer-auction interaction data
Auction attribute data

3 – **Physical design** (translating logical data model for target DBMS)

- Has been done simultaneously (in part) with the above as know capabilities of MySQL
- Base relations in current form can all be represented in MySQL fine
- Discussion of design representation of derived data:
    - Doesn't technically break 3NF for parents to include summarised data from child entities, but goes against spirit of normalisation by introducing redundancy and complexity
    - Might give performance advantages, especially for those which are accessed more than they are updated (e.g. numBids), and performance is critical in eCommerce applications
    - Reduce complexity and query in real-time when needed, but keep this as an option if performance is unsatisfactory – very important for eCommerce sites
- General constraints: additional constraints to ensure data integrity:
    - Usernames must be unique across both buyers and sellers (so don't have 'UNIQUE' constraint in table creation)
        - Implemented using triggers (one each for Buyers and Sellers)
    - Start date must be after create date
        - Implemented at table creation
    - End date must be later than start date
        - Implemented at table creation
    - Reserve price must be greater than start price
        - Implemented at table creation
    - Bids should be greater than current max bid + minIncrement (or start price if no bids)
        - Implemented using a stored procedure and a trigger
- *And lots more possible…*
    - Don't delete seller account if have active auctions
        - *For current implementation, not allowing buyers to delete accounts*
        - *Could be added later with a trigger/stored procedure*
    - Don't delete buyer account if currently a leading bidder on an auction
        - *For current implementation, not allowing sellers to delete accounts*
        - *Could be added later with a trigger/stored procedure*
    - Etc.
- In general, when checking for data integrity, check on client-side (CS) for everything (important to both client (e.g. passwords match) or system itself (e.g. max length)) and server-side (SS) only for things that matter to the system. If a user circumvents the CS checks, a bad result is 'on them'. Check on CS for a good user experience (so they don't get unexpected errors after form submission, for example), and check on the SS in case individuals circumvent CS checks.
    - Online quote: *The rule is to control server side what actually matters for the server, and client side what matters for user. For example, if you want to allow only certain characters in password and a maximum length, this should be controlled server side. If you just want to be sure that the user knows what he/she has just typed, client side controls are fine.*
    - *Some controls can be done twice, because what matters for the server is the data, but what matters for user is to be warned of an error as soon as possible. For example it is fine to first*

control the validity of a field client side as soon as the field has been typed in to immediately warn the user, and then control it server side when the form is submitted.

- On the SS, can check in PHP and/or MySQL server code itself.
    - For core functionality issues (e.g. bidding validity, usernames) can keep the check functionality in the server (e.g. function) since static and simplifies PHP code (thereby reducing chance of mistakes).
    - Also allows other front-ends (e.g. apps) to re-use functionality and guarantee that basic data integrity is being maintained.
- Also refer to bookmarked article
- Overall, best to check in both PHP and SQL for robustness