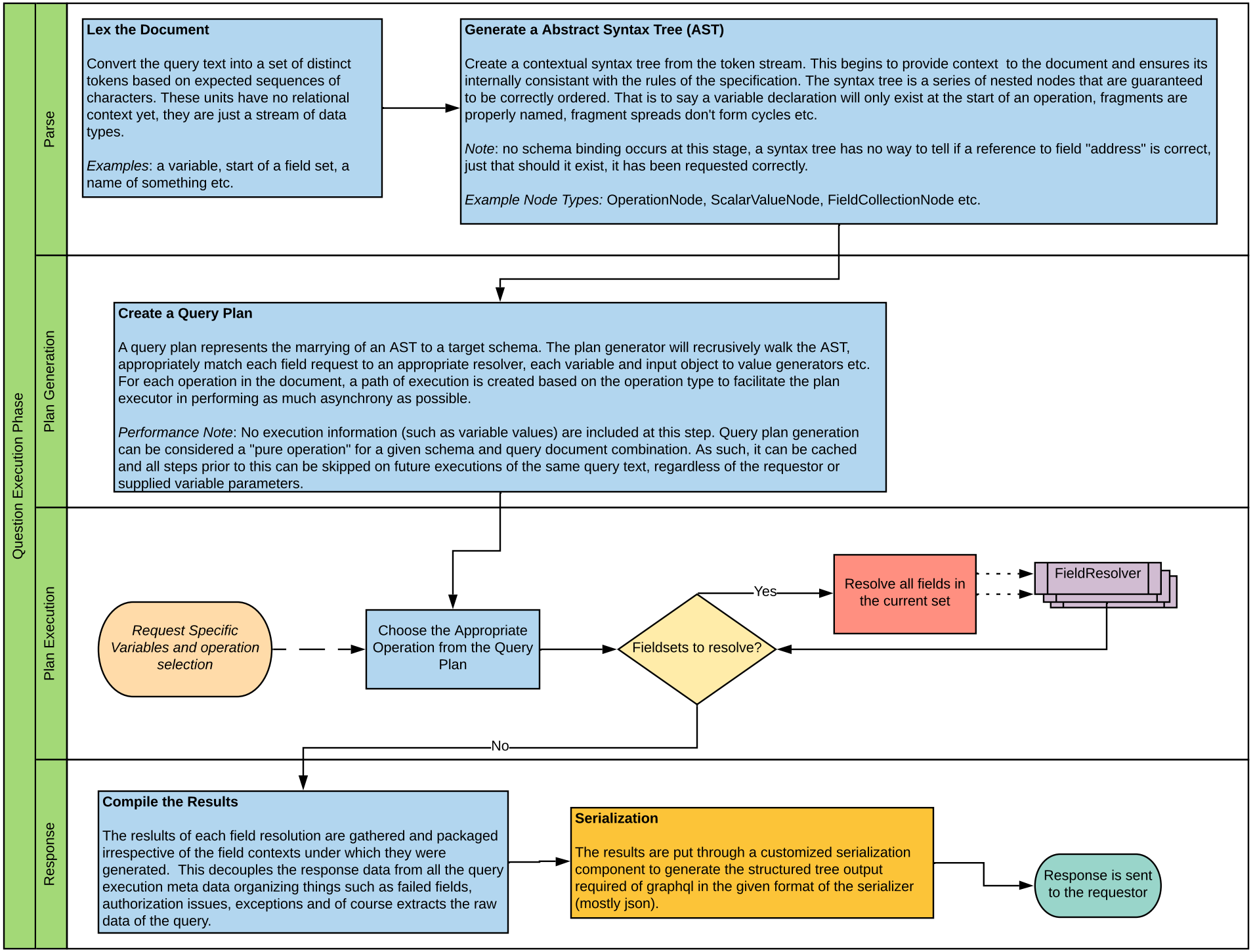
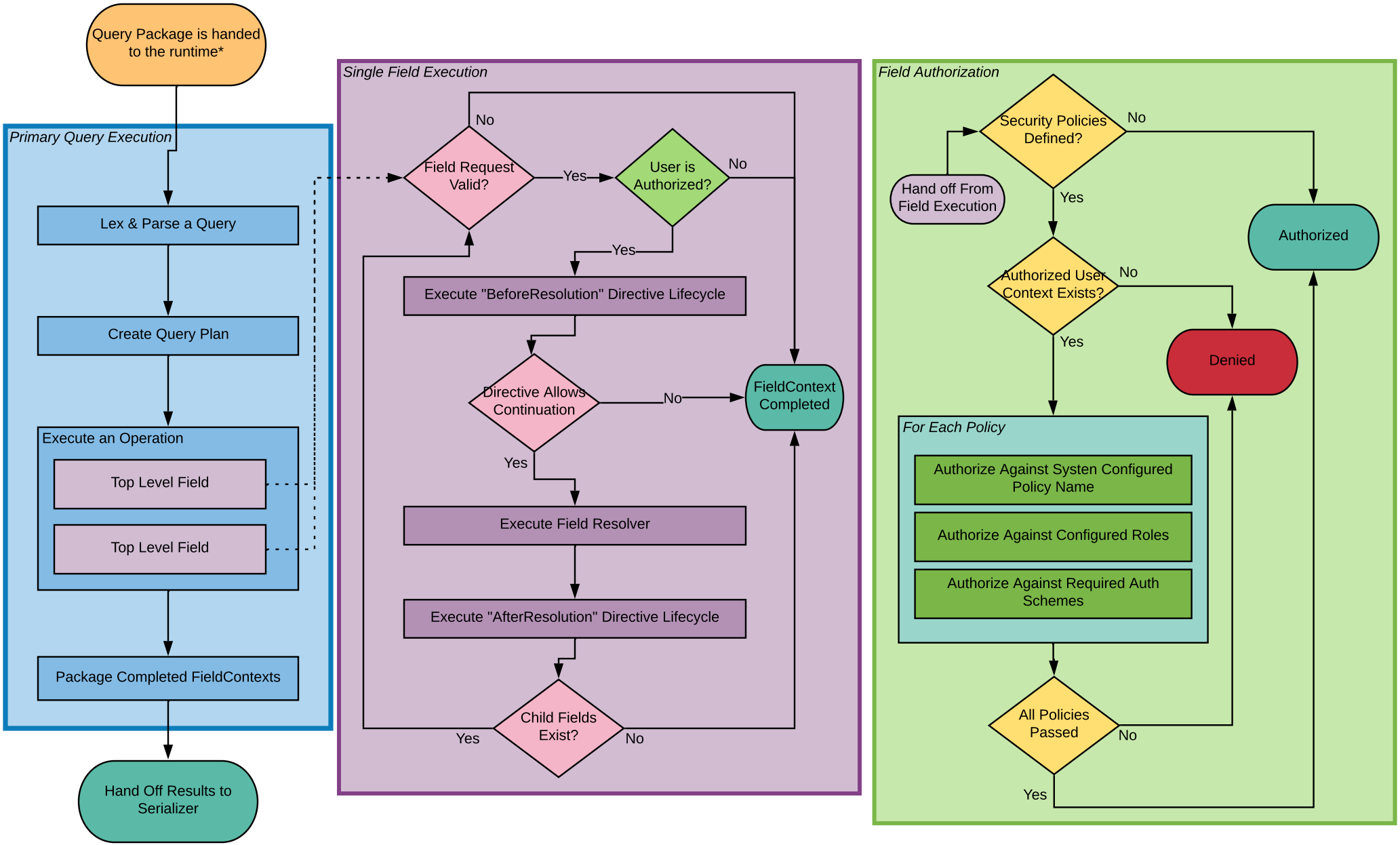
Graph Query Execution

When a query (or mutation) is received from a client it is handed off to the graphql runtime where a set series of steps are executed to fulfil the request. In general these steps are grouped into four distinct phases and executed as follows.



Request Processing

This diagram illustrates the conceptual activities, segmented by middleware pipelines, for completing a single query.



*Invocation of the GraphQL ASP.NET runtime is traditionally done via an HttpProcessor mapped to an URI via ASP.NET, however; this is simply a convience interation point. The runtime can be safely invoked anywhere as long as the correct data fields are supplied to it.

Primary Middleware Pipelines

GraphQL ASP.NET performs its query resolutions, from start to finish, in a set of 3 middleware pipelines that perform small incremental actions on a data context in order to produce a result. This diagram contains a description of the default steps included in each pipeline. All pipelines are extensible via startup configuration settings.

Query Execution Pipeline

The primary workflow of a query. The ASP.NET runtime will hand off the raw data of the request (the query text and variable package) from a caller to this pipeline for processing.

This pipeline passes forward a `GraphQueryExecutionContext` containing top level describing the request data and the authorized user, if any.

`ValidateQueryRequest`

Ensures that the request data, handed off from ASP.NET, could be completed in its current state. I.E. is the query text not blank, was pipeline context properly generated and supplied etc.

`RecordQueryMetrics`

Manages the performance metrics of the plan starting the clock and ending any performance counters still running as the pipeline unwinds.

`ParseQueryDocument`

Lexes and parses the document text into a syntax tree, which is attached to the context.

`GenerateQueryPlan`

Creates and attaches a qualified query plan to the context.

`AssignQueryOperation`

Extracts and validates the operation requested by the user, assignng it to the execution context.

`QueryAuthorization`

This component will invoke the authorization pipeline for every "secure" field (those that define auth rules) on the chosen operation and approve or deny the user access to execute the query as a whole.

`ExecuteQueryOperation`

Spawns and completes set of Field Execution Pipelines for each field in the requested operation. The results of each are attached to the execution context.

`PackageQueryResult`

Packages the completed field execution results into a final `IGraphOperationResult.`

Field Execution Pipeline

For any field that needs to be resolved (i.e. when data is needed from user code to fulfill a graph query), each field is processed through its own pipeline to invoke the user's code in a secure and isolated manner.

This pipeline passes forward a `GraphFieldExecutionContext` containing all required field level data.

`ValidateFieldExecutionRequest`

Ensures that the request for the individual field can be completed in its current state. I.E. given the supplied source object a mapped resolver exists that can handle the request and all the required parameterized information for said resolver is present.

`FieldAuthorization`

When included, depending on the developer's runtime configuration, this component will invoke the field field authorization pipeline for the single field in context approving or denying the user on the context access to the data field.

`ResolveDirectives`

Any directives attached to or decorating the field execute their "BeforeResolution" lifecycle method. When necessary, any required exits are obeyed and the pipeline immediately terminates.

As the pipeline unwinds, this middleware component executes a second "AfterResolution" lifecycle methods for any post processing the directives may with to complete. This is dependent on the query being executed and the directives created by the developer.

`ResolveField`

The field resolver itself (the developers's code) is invoked and the results are recorded to the field context.

Field Authorization Pipeline

For any field that needs to be resolved, each field is processed through its own pipeline to invoke the user's code in a secure and isolated manner.

This pipeline passes forward a `GraphFieldAuthorizationContext` containing the metadata to complete an authorization check.

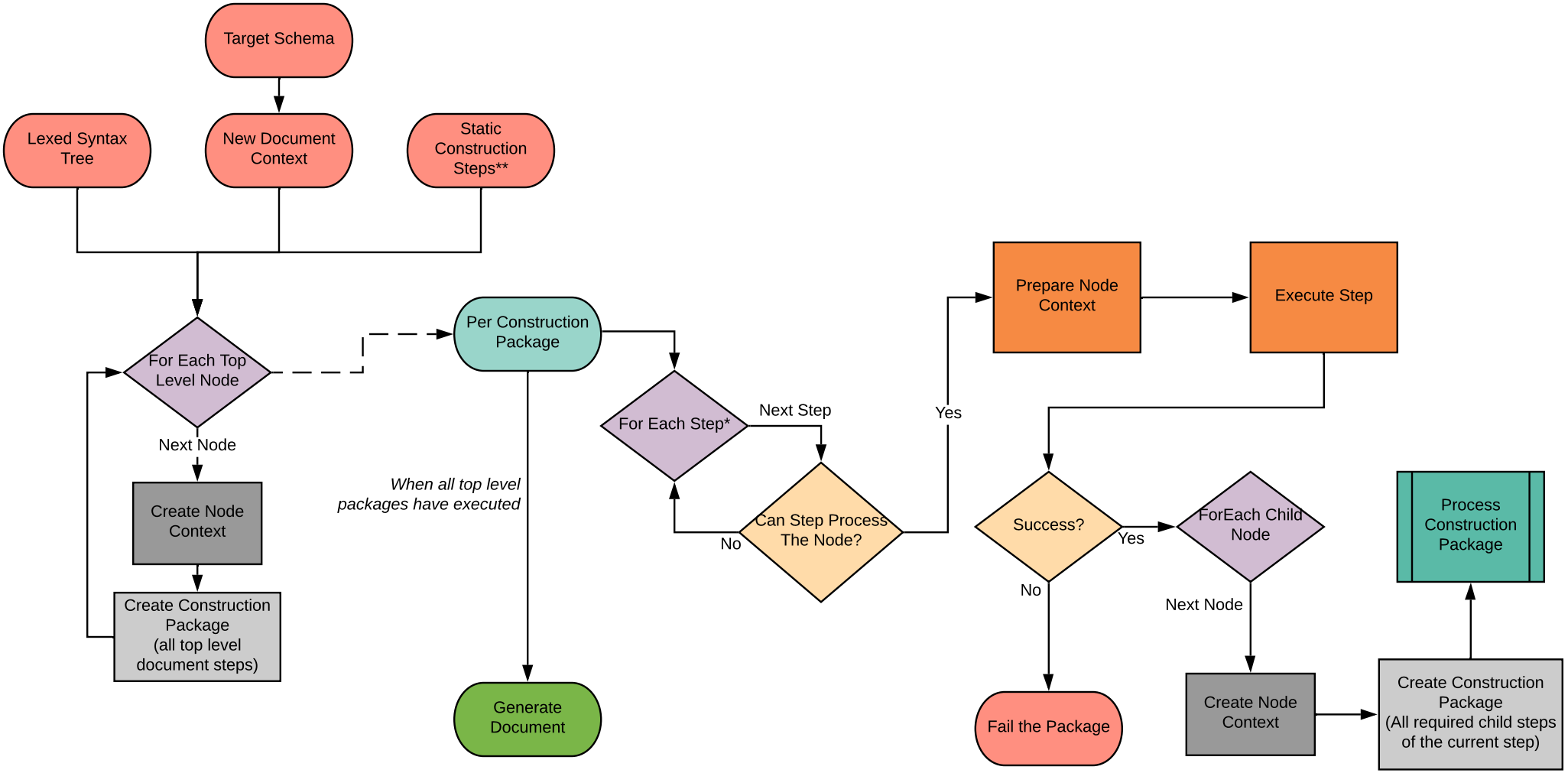
`FieldAuthorizationCheck`

Inspects the security groups and policies attached to the field ensuring the user on the authorization context matches/passes the rules in scope. A Success/Fail result is ultimately sent back to the middleware component that invoked this pipeline.

This document represents the middleware component order in its default configuration. Out of the box, GraphQL ASP.NET can support either authorization scheme (field or query level) on a "per schema" basis. Each pipeline can be extended, interjected or completely changed to suit the developer's needs.

Document Creation

Once the provided query is lexed it's passed to the document creator which will traverse the syntax tree and, combined with the schema, internal construction steps and the graphql specification rules, build out a document that can be executed to generate resultant set to the query.



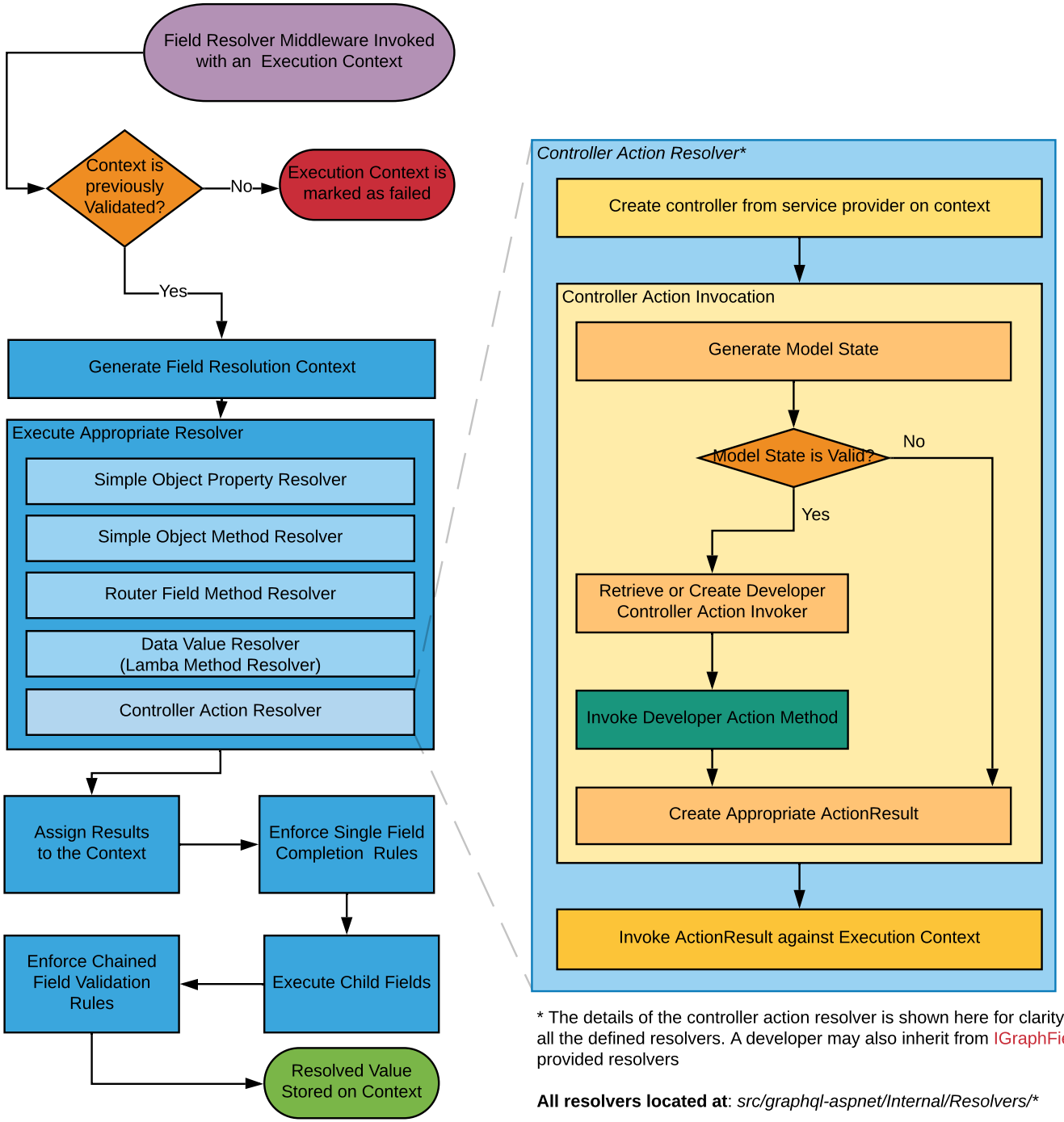
* A step is a predefined rule that performs some action against a node in the syntax tree. This could be building a piece of the document or enforcing a requirement of the specification.

Example steps are "Validate Name", "Attach child FieldSelectionSet ", "Create Variable Reference"

src/graphql-aspnet/Defaults/DefaultGraphQueryDocumentGenerator{TSchema}.cs

Invoking a Single Field Resolver

This diagram illustrates how a single field is eventually resolved marrying the library internal code to the developer's code for performing meaningful business logic.



Resolver Descriptions

Object Property Resolver: Extracts a single value of a single property from the source object.

Object Method Resolver: Executes a single public method on the source object and uses the result as the result.

Route Field Method Resolver: An internally used resolver to handle virtual fields generated to support the developer's requested graph structure when the developer doesn't specifically create a controller action for each level of their graph hierarchy

Data Value Resolver: Similar to the method resolution this resolver executes a supplied lambda to perform some action and generate a result.

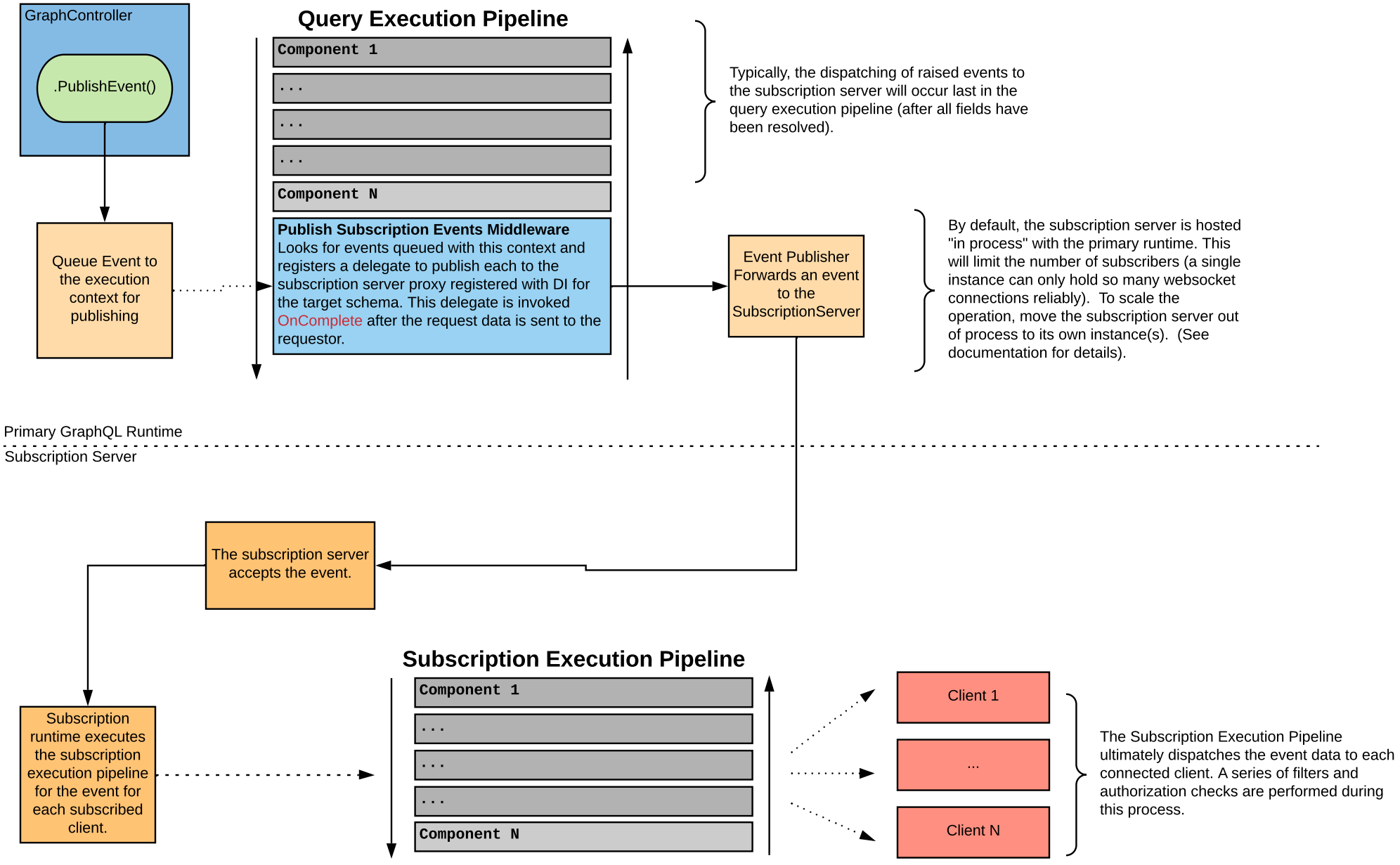
Controller Action Resolver: Executes an ASP.NET MVC style controller with appropriate model level validation and processing of generated ActionResults.

* The details of the controller action resolver is shown here for clarity of process. It is the most used and most complex of all the defined resolvers. A developer may also inherit from IGraphFieldResolver and create new or replace any default provided resolvers

All resolvers located at: *src/graphql-aspnet/Internal/Resolvers/**

Raising a Subscription Event

This diagram illustrates how a named event is raised from a GraphController and is passed to a superscription server and delivered to a connected ciient.

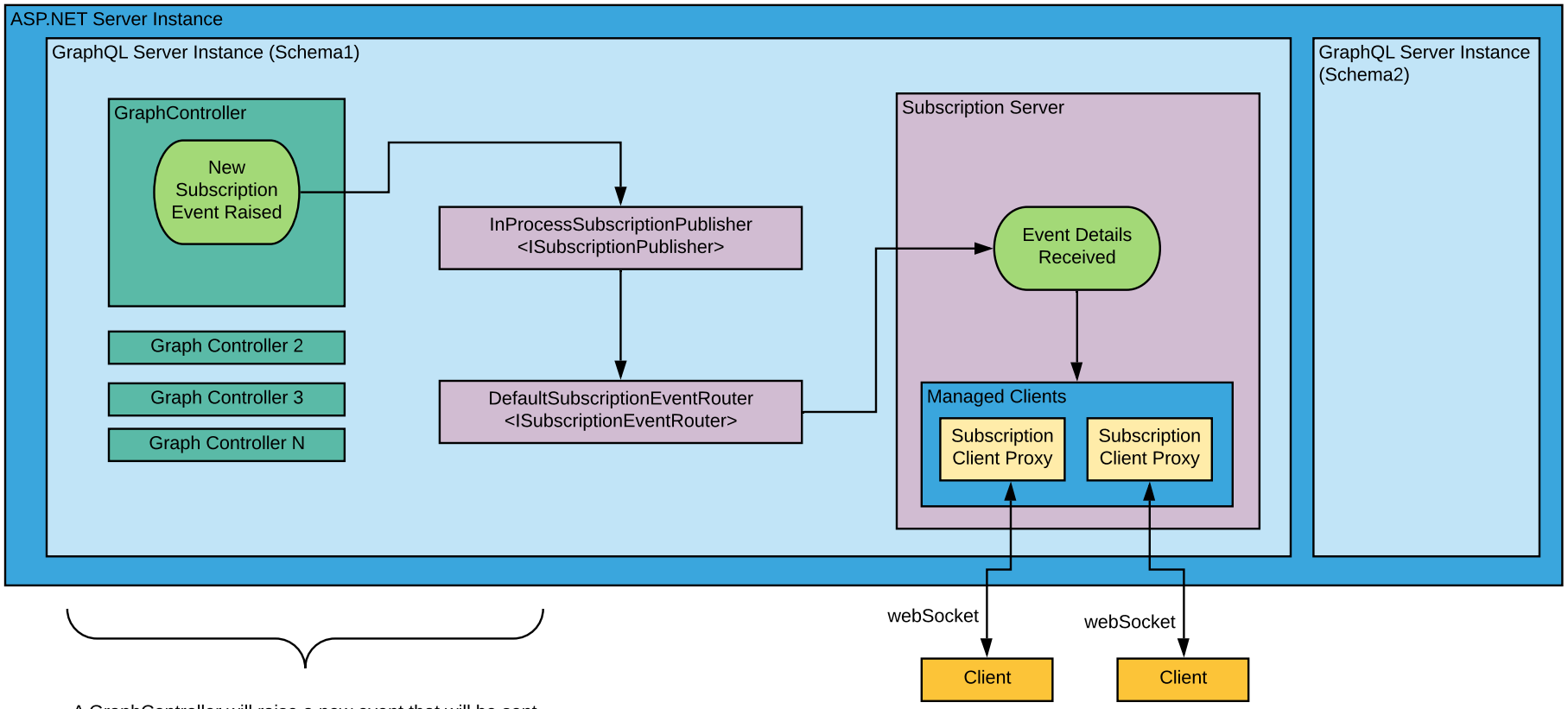


Subscriptions (In Process)

This diagram represents the primary logical components of the graphql subscription server when it is hosted in the same instance as the primary runtime.

Pros: No moving parts. The subscriptions are hosted right along side your query/mutation requests. There is near zero delay from when a subscription event is raised to when its dispatched to a subscription.

Cons: This solution provides no scalability. For smaller implementations this may work fine. If you ever have to introduce a second GraphQL server to balance query load or reach a prohibitive number of websocket connections this solution will fail. When scaled horiztonally some subscribed clients will not receive events raised by another server instance.



A GraphController will raise a new event that will be sent to the subscription server for distribution via an inprocess publisher and router. Events are not published beyond the boundry of the ASP.NET server instance.

Subscriptions (Out of Process)

This diagram represents the primary logical components of the graphql subscription operation and how the primary runtime interacts with the server(s) hosting the websocket connections.

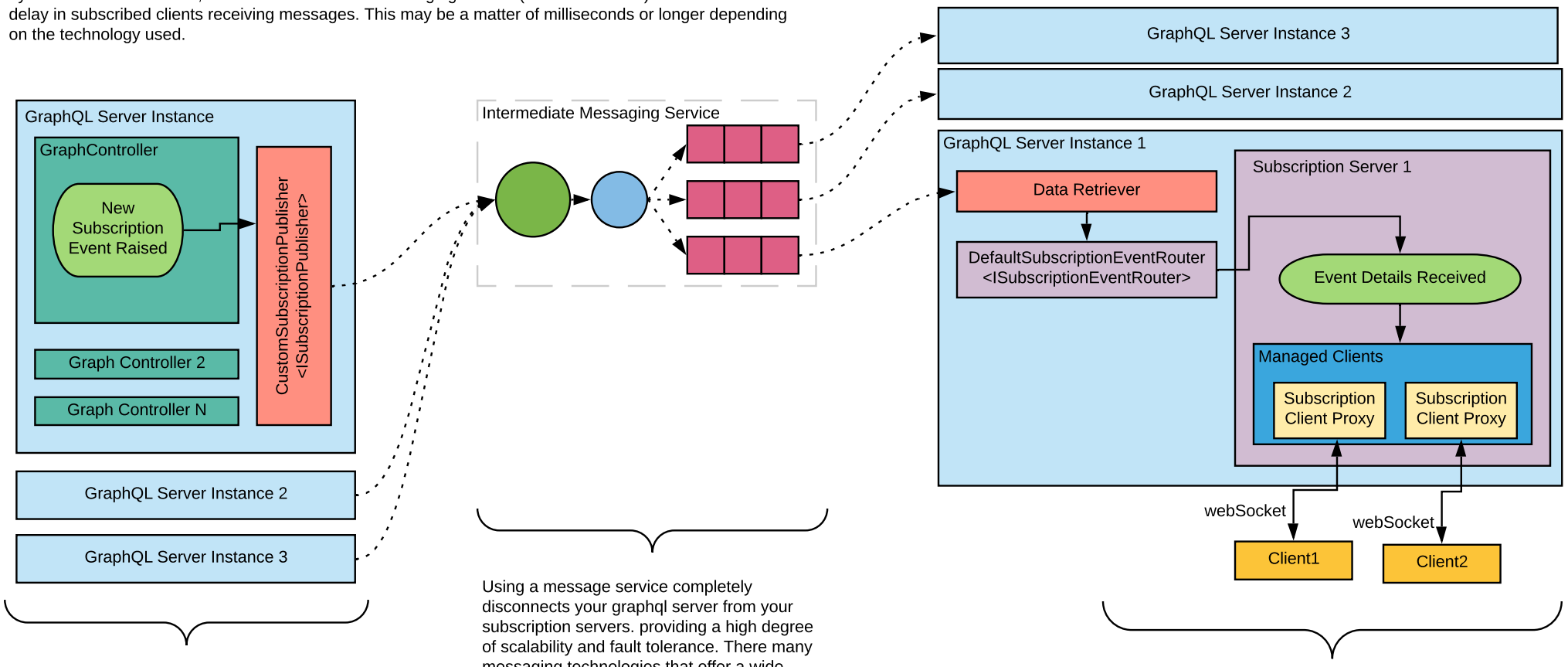
PROS: This approach gives you a high level of scalability by using an intermediary (like a broked message queue) to completely disconnect the graphql query/mutation server from the subscription server instances. Each "raised event" is emmited once by any given query server and the event is delivered to each server listening for it.

CONS: This approach is more complex to implement (it has more moving parts) and requires an out of process mechanism to manage messages and process events. Your graphQL subscriptions will be limited by such constraints. Also, use of an intermediate messaging service (or database etc.) will introduce some delay in subscribed clients receiving messages. This may be a matter of milliseconds or longer depending on the technology used.

An out of process subscription server requires creating two components:

Subscription Publisher: Implement *ISubscriptionPublisher* and deliver subscription events to some intermediate data source like a message queue. This object must be registered with your DI container.

Data Retriever: Create some sort of data retrieval process such that each server instance can pull a copy of a subscription event when needed. Deserialize the event and forward it to the server's ISubscriptionEventRouter (available through DI). You do not need to perform any processing on the message other than deserializing it.



Under high loads you may have multiple, load-balanced instances of your application. Any of which may raise events at any time.

Moving the subscription operations out of process to their own server instance(s) helps to manage the stateful websocket connections more effectively.

Using a message service completely disconnects your graphql server from your subscription servers. providing a high degree of scalability and fault tolerance. There many messaging technologies that offer a wide range of features for different scenarios.

Potential Tech: Redis, RabitMQ, MSMQ, Azure Service Bus, Amazon MQ

In this setup, the data retriever is a custom built IHostedService that monitors a message queue.

The data retriever then deserializes subscription events from the queue and forwards them to the internal router to be processed and distributed to any connected clients.